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EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR ENERGY

DIRECTORATE D Nuclear Energy
**D4 – Radiation protection**

# REPORT

# VERIFICATION UNDER ARTICLE 35 OF THE EURATOM TREATY

**Former uranium mines and production sites**

**Departments of Haute-Vienne and Limousin Region**

**FRANCE**

**14 to 17 September 2010**

**Reference: FR-10/06**

**VERIFICATION PERFORMED UNDER ARTICLE 35**
**OF THE EURATOM TREATY**

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|---|---|
| INSTALLATIONS: | Environmental radioactivity monitoring installations around former uranium mine sites and uranium extraction residue storage sites in the Limousin region. |
| IMPLEMENTATION: | Limousin region |
| DATE: | From 14 to 17 September 2010 |
| REFERENCE: | FR-10/06 |
| REPORT DATE: | 30 Nov. 2010 |
| INSPECTORS: | C. Gitzinger (team leader)<br>E. Henrich<br>E. Hrnecek |

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*[signed]*

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# TECHNICAL REPORT

ABBREVIATIONS AND DEFINITIONS

| | |
|---|---|
| AFSSET | French Agency for Environmental and Occupational Health Safety |
| ALGADE | ALpha GAmma DElta (company created in 1993, inheriting the radiation protection teams from the French Atomic Energy and Alternative Energies Commission for uranium mines) |
| ANDRA | National Agency for Radioactive Waste Management |
| ARALEP | Pollution Expertise Research Application |
| AREVA NC | AREVA subsidiary specialising in the nuclear fuel cycle |
| ASN | Nuclear Safety Authority |
| ASN/DEU | Nuclear Safety Authority – Directorate of Environment and Emergencies |
| BDE | Decennial Environmental Report (established by AREVA NC at the request of the prefect for Haute-Vienne) |
| BRGM | Bureau of Geological and Mine Research (leading public institution in the field of earth sciences) |
| BU | Business Units (inherent to AREVA NC) |
| CARSO | French Group of laboratories providing analytical services for quality of the environment and life |
| CEA | French Atomic Energy Commission ("and Alternative Energies" added to the name in late 2009) |
| CESAAM | Centre for Studies and Monitoring of Ancient Mining Activities, in 2010 became the Direction de l'Après Mines [post mining authority] (DAM). |
| CFM | Compagnie Française de Mokta; Cogéma 100% (purchased from Imétal); mining company |
| CLIS | Local Information and Monitoring Committees (for mining sites) |
| COFRAC | COmité FRançais d'ACcréditation [French Accreditation Committee] |
| COGEMA | COmpagnie GÉnérale des MAtières nucléaires [General Company for Nuclear Materials] |
| DAM | Directorate of Post Mining Operations - Direction de l'Après Mines |
| DARQSI | Directorate of Regional Action, Quality and Industrial Safety (for MEEDDM) |
| DDASS | Departmental Directorate of Health and Social Affairs |
| DDSV | Departmental Directorate of Veterinary Services |
| DEI | Directorate for the Environment and Intervention (for the IRSN) |
| DG ENER | Directorate General for Energy (for the EC) |
| DG TREN | Directorate General for Energy and Transport (formerly a DG of the EC) |

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|---|---|
| DGAC | Directorate General for Civil Aviation (for MEEDDM) |
| DGAL | Directorate General of Food |
| DGALN | Directorate General of Planning, Housing and Nature (for MEEDDM) |
| DGEC | Directorate General for Energy and Climate (for MEEDDM) |
| DGITM | General Directorate of Infrastructure, Transport and the Sea (for MEEDDM) |
| DGPR | Directorate General for Risk Prevention (for MEEDDM) |
| DGSNR | Directorate General for Nuclear Safety and Radiation Protection [until the creation of the ASN (Nuclear Safety Authority) in June 2006] |
| DIREN | Regional Directorates for the Environment |
| DRE | Regional Directorates for Facilities |
| DREAL | Regional Directorates for the Environment and Spatial Planning and Housing |
| DRIRE | Regional Directorates for Industry, Research and the Environment |
| DSCR | Directorate of Road and Traffic Safety (for MEEDDM) |
| EC | European Commission |
| EDF | Electricité de France [French national electricity board] |
| EURDEP | EUropean Data Exchange Platform |
| EURODIF | EUROpean gaseous DIFfusion uranium enrichment consortium |
| GEODERIS | Public Interest Group (GIP) instituted between BRGM and INERIS. Provides post-mining assistance and expertise to the state (central administrations and decentralised services, particularly the DREAL) |
| GEP | Pluralistic Expertise Group |
| HPGe | High Purity Germanium (gamma ray detector) |
| IAEA | International Atomic Energy Agency |
| ICP | Inductively Coupled Plasma |
| ICPE | Classified Installations for Environmental Protection |
| ICP-MS | Inductively Coupled Plasma - Mass Spectroscopy |
| ICP-OES | Inductively Coupled Plasma – Optical Emission Spectroscopy |
| INERIS | National Institute for Industrial Environments and Risks |
| InVS | Institute for Public Health |
| IPSN | Institute of Nuclear Safety and Protection (became IRSN as of 2002) |
| IRSN | Institute for Radiological Protection and Nuclear Safety |
| ISO | International Organisation for Standardisation |
| IT | Information Technology |
| LA | Low Activity |
| LAB | Test Laboratory division (SEPA division at AREVA NC) |
| LCSN | Laboratory of Chemistry for Natural Substances (for the University of Limoges) |

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|---|---|
| LEA | Standard Laboratory Activity (for CERCA) |
| LIMS | Laboratory Information Management System |
| MEDAD | Ministry of Ecology, Sustainable Development and Spatial Planning |
| MEEDDAT | Ministry of Ecology, Energy, Sustainable Development and Territorial Planning |
| MEEDDM | Ministry of Ecology, Energy Sustainable Development and the Sea |
| MIMAUSA | Memory and Impact of Uranium Mining: Synthesis and Archive |
| MINEFI | Ministry of Economy, Finance and Industry (1997-2007) |
| MSNR | Radiation Protection and Nuclear Safety Mission for MEEDDM |
| NF | Norme Française [French standard] |
| OCM | Open-Cast Mining |
| OHSAS | Occupational Health & Safety Advisory Services |
| OJ | Official Journal (of the EC) |
| PAE | Potential Alpha Energy |
| PNGMDR | National Plan for the Management of Radioactive Waste and Materials |
| PPRM | Prevention Plans for Mining Risks |
| QAP | Quality Assurance Plan |
| R&D | Research and Development |
| REGe | Reverse Electrode Germanium (high purity germanium with zone N+ at centre – gamma ray detector) |
| REM | Radioactivity Environmental Monitoring |
| RGIE | General Regulations for Extractive Industries |
| RNM | National Network for the Measurement of Radioactivity in the Environment |
| RSE | Environmental Monitoring Network |
| SAN | Analysis division (for SEPA) |
| SARA | Automated Monitoring of Radioactivity in Aerosols |
| SCPRI | Central Service for Protection against Ionizing Radiation |
| SEPA | Service of Process Studies and Analyses (for AREVA NC) |
| SET | Studies division (for SEPA) |
| SNCF | Société Nationale des Chemins de fer Français [French National Railways] |
| SPI | Industrial Steering division (for SEPA) |
| STC | EURATOM Scientific and Technical Committee |
| TLD | Thermo-Luminescent Dosimeter |
| UMW | Underground Mine Workings |
| VLA | Very Low Activity |
| XRF | X-Ray Fluorescence |

# 1. INTRODUCTION

Article 35 of the Euratom Treaty specifies that all member states must provide the necessary installations for permanently monitoring atmospheric radioactivity and water and soil levels, as well as ensuring that basic standards are respected to protect the health of the population and workers against dangers deriving from ionizing radiation[1].

Under the provisions of Article 35 of the Euratom Treaty, the European Commission has the right to inspect the operation and effectiveness of the facilities named above.

Within the European Commission, the Directorate General for Energy (DG ENER; formerly the Directorate General for Energy and Transport - DG TREN) is responsible for implementing inspections under the provisions of Article 35 of the aforesaid treaty.

To perform this inspection, a DG ENER team from the European Commission travelled to France from 13 to 17 September 2010, to visit the environmental radioactivity control facilities in the vicinity of the former uranium mines and old uranium production sites in the Limousin region, as well as two of the laboratories involved in this monitoring operation.

The goal of the verification was to provide an independent assessment of the effectiveness of the facilities, systems and organisation set up to ensure the monitoring of:

- Radioactive releases into the environment;
- Radioactivity levels in the environment around uranium mining sites;
- National radioactivity levels.

The verification examined the operation of regulatory systems for measuring the release of radioactivity, and the environmental monitoring programmes applied at former uranium mining sites and uranium production sites, as well as nationwide. Aspects dealing with maintenance, calibration, registration, archiving and data transmission were verified by ad hoc testing. To the extent that it is difficult to go into extreme detail for each of these points, the verification also examined the existence and implementation of quality assurance programmes and internal and external audits.

The verifications were performed according to the procedures defined in the Commission's communiqué [2] and in conformity with the 1992 protocol, specifying the general principles for the implementation of inspections by the European Commission relating to facilities for measuring environmental radioactivity across France.

## 1.1 PREPARATION AND IMPLEMENTATION

In February 2010, the European Commission announced in a letter (ref. TREN.H4 CG/jf D(2010)51703) to the Permanent Representation of France to the European Union, its

1 Council Directive 96/29/Euratom of 13 May 1996 establishing basic standards related to the health protection of the public and workers against ionizing radiation (OJ L 159, 29.6.1996, p. 1).

2 Verification of control facilities for environmental radioactivity under the provisions of Article 35 of the Euratom Treaty - Practical arrangements for conducting verification visits in member states (OJ C 155, 4.7.2006, p. 2).

intention to subject France to a verification under the provision of Article 35 of the Euratom Treaty, monitoring former uranium mining sites and uranium production sites in the Limousin region. In this letter, the European Commission had expressed its wish to extend verification activities to waste monitoring devices and radiochemistry laboratories and their records, with the aim of achieving a better overall understanding of the environmental monitoring process.

The Euratom Scientific and Technical Committee (STC), which is part of the Prime Minister's department and whose duties include the implementation of the Euratom Treaty at national level, led the preparation of the verification visit by ensuring the coordination of the various French entities involved and the European Commission. These exchanges enabled the preparation of the verification and ensured its proper smooth application by discussing the practical procedures of its implementation. To facilitate the verification team’s work, the STC also transmitted a technical file before the verification. Additional documents were made available on site, during the verification procedures.

The verification team also relied on general data related to the monitoring of environmental radioactivity at former uranium mining and production sites in France, published on the IRSN website.

## 1.2 PROGRAMME

The programme of the visit, agreed between the parties, is attached (annex 1).

## 1.3 DOCUMENTATION

A list of the documents made available to the verification team is attached (annex 2).

## 1.4 CONTACTS

During the verification, discussions were held with representatives of the Euratom Scientific and Technical Committee (STC), the Nuclear Safety Authority (ASN), representatives of the Ministry of Ecology, Energy Sustainable Development and the Sea (MEEDDM), representatives of the Regional Directorates for the Environment and Spatial Planning and Housing (DREAL), the Institute for Radiological Protection and Nuclear Safety (IRSN), and the operator’s representatives (AREVA NC). The laboratories carrying out measurements and analyses for the operator were included in the verification. The verification team acknowledges the excellent spirit of these exchanges.

The following persons were interviewed:

**<u>Euratom Scientific and Technical Committee (STC)</u>**

| | |
|---|---|
| Bruno Quaglia | Head of the Euratom Scientific and Technical Committee |

**<u>Nuclear Safety Authority (ASN)</u>**

| | |
|---|---|
| Jean-Jacques Diana | ASN/DEU Directorate of Environment and Emergencies |
| Géraldine Dandrieux | Assistant Director of research facilities and waste |
| Stéphane Le Gal | Not communicated |
| Odile Palut-Laurent | Not communicated |

**<u>Ministry of Ecology, Energy, Sustainable Development and the Sea (MEEDDM)</u>**

| | |
|---|---|
| Frédéric Seigle | Project Manager |

**Regional Directorates for the Environment, Spatial Planning and Housing (DREAL)**

| | |
|---|---|
| André Dubest | Head of the pollution prevention, risk control and transport service |

**Institute for Radiological Protection and Nuclear Safety (IRSN)**

| | |
|---|---|
| Guillaume Manificat | Head of the Environmental Radiological Monitoring Laboratory |
| Jérôme Guillevic | Head of the Evaluation Bureau for Risks related to Natural Radioactivity |

**AREVA NC –Bessines facility**

| | |
|---|---|
| Guy LAURET | Director of the Bessines facility |
| Christian Andres | Environmental Services Coordinator |
| Caroline Benesteau | Engineer responsible for environmental monitoring |
| Laurence Chabanne-Pouzinin | General Counsel Public, Nuclear and Environmental Law |
| Bernard Barreau | Water Services Coordinator |
| Baptiste Buet | European Affairs, International and Marketing Management, AREVA SA |
| Philippe Crochon | Environmental and Social Responsibility Management, BG Mines |
| Patrick Devin | Safety, Health and Environmental Safety Management, AREVA NC |
| Remi Moulin | Water Services Technician |
| Julien Bigot | Water Services Technician |
| Jacques Gesset | Technician responsible for the Jouac site |

**SEPA Laboratory (AREVA NC)**

| | |
|---|---|
| Pascal Nardoux | Laboratory Coordinator |

**ALGADE Laboratory (subcontracted by AREVA NC)**

| | |
|---|---|
| Sylvain Bernhard | Laboratory Coordinator |

**Pe@rL (subcontracted by AREVA NC)**

| | |
|---|---|
| Vincent Thomas | Not communicated |
| Vincent Delpech | Not communicated |

# 2. URANIUM MINES IN FRANCE

## 2.1 GENERAL HISTORIC OVERVIEW

Analysing the documentation received before the visit, the verification team learned that the development of uranium extraction, the newest mining industry in France, began after WW II within a political context of reconstruction. The desire to regain a sense of national independence made uranium an essential vehicle, first and foremost for establishing a nuclear weapons programme, and for developing nuclear technology for the production of electricity. The extraction of uranium was, like the entire programme, originally entrusted to the Atomic Energy and Alternative Energies Commission (CEA), which was set up for this purpose in 1945.

Exploration on French territory quickly led to the first discoveries of large deposits – the Henriette mine in the Limousin region in 1948, followed by the Bois Noirs in Monts du Forez in 1954. These discoveries in turn directed research towards all granitic mountainous areas (the Massif Central and Massif Armoricain). The extension of research to geologically different areas (sedimentary formations) subsequently allowed for additional discoveries, such as Hérault. By the late 1960s, the main mining divisions of Crouzille in the Limousin region, Vendée in the west, Forez and Hérault, had been created and were being exploited by the CEA, and progressively, more or less locally by other producers (subsidiaries of public or private companies).

After its heyday in the 1980s (1988 proved to be a record year with 3 420 tonnes of uranium extracted in France, amounting to 5.6 % of global production, estimated at 61 000 tonnes), economic constraints and depleted deposits put an end to the extraction of natural uranium in France during the 1990s. The Jouac/Bernardan mine in Haute-Vienne, the last French extraction site, was closed in 2001. The industrial exploitation of uranium in France lasted nearly fifty years.

For half a century, the exploitation of uranium resources allowed for the extraction of 52.5 million tonnes of mineral ore, for total production of around 76 000 tonnes of uranium.

Hence, activities involving the exploration, extraction and processing of uranium ore, as well as the storage of processing residue in France were spread over 210 sites distributed over 25 different departments. Considering the number of sites, their geographical distribution, and the diversity of situations encountered, for all practical purposes it is in fact difficult to provide a complete overview of uranium mining activities in France, with the aim of assessing their environmental impacts.

The team was informed that, with the exception of a limited number of sites that have now been abandoned (currently estimated at about ten sites), the majority of sites have progressively been brought together under the responsibility of the CEA firstly, followed by its industrial subsidiary COGEMA (General Company for Nuclear Materials) upon its creation in 1976, and finally under AREVA NC (created in 2001 from the merger of COGEMA and other nuclear concerns). This industrial stakeholder, historically the main operator of French uranium mines, remains present today as an operator in a legal sense, notably through its subsidiary AREVA NC, over all sites where an operator remains.

With the aim of acquiring a complete source of information on the administrative situation and possible radiation monitoring devices around sites affected by uranium mining, the Directorate for the Prevention of Pollution and Risks (DPPR) for the Ministry of Ecology, Energy Sustainable Development and the Sea (MEEDDM), requested that the IRSN set up a programme on this issue.

Under the MIMAUSA programme (Memory and Impact of Uranium Mining: Synthesis and Archive) the IRSN has undertaken a complete census of all former uranium ore exploration, extraction and processing sites in France. The programme was launched in 2003 and has been conducted in close partnership with AREVA NC. Its steering committee includes the following: DPPR (Directorate for the Prevention of Pollution and Risks) and DARQSI (Directorate of Regional Action, Quality and Industrial Safety) for MEEDDM, as well as the ASN, IRSN and AREVA NC, DREAL Auvergne and Limousin, and the Bureau of Geological and Mine Research (BRGM).

All available data have been accessible since 2009 via a map interface on the IRSN website.

Based on an analysis of the documents received before the visit, the verification team found that this inventory allowed for the following general overview to be drawn:

Around 215 sites are situated in France, spread over 25 departments. These sites have been affected by the following activities, with differing consequences depending on the scope of activities:

- Mining exploration
- Extraction of mineral ore
- Processing of mineral ore at 8 sites with mills
- Storage of processing waste at 16 sites

Mined deposits presented relatively low levels of uranium (a little over 1000 ppm, i.e. 1000 grams of uranium per tonne of mineral ore. This is around 1000 less than the deposits currently extracted in Canada).

In total, 52 million tonnes of mineral ore extracted from French mines were processed to produce 76 000 tonnes of uranium. To obtain these 52 million tonnes of mineable ore, roughly 170 million tonnes of rock had to be extracted from the ground, defined as so-called mine ‘tailings’, i.e. with a level of uranium equal to zero or in any case too low for industrial use.

The term ‘tailings’ refers to sterile rock excavated to access ore deposits. Nothing distinguishes tailings from rocks present in the areas concerned, except they are generally richer in uranium due to their location near the mineralised areas.

The team was informed that the levels of uranium from tailings range from very low values (a mere few g/t or ppm) for tailings made of ordinary rocks surrounding the deposit, and higher values (a few hundred g/t or ppm) for selective tailings from uranium extracts; the latter correspond to rock residue whose uranium content is too low (lower than a “cut threshold”) to be considered mineral ore. The cut threshold value has evolved over time in relation to uranium prices and extraction techniques. During the early 1990s, with collapsing rates, the cut threshold thus went from 100 to 400 ppm for open-cast mining, and 200 to 400 ppm for underground mines.

Uranium deposits are situated mainly around the edge of the Massif Central, as well as in the Vendée area, in Brittany, Alsace, and to a lesser extent in the Alps and Aquitaine (Figure 1).

Many of the sites are small and produced low quantities of uranium. Less than twenty of the sites produced over 1 000 tonnes. The most important sites were situated in the Limousin region (Haute Vienne), Languedoc-Roussillon (Hérault and Lozère), Auvergne (Loire, bordering with Allier, Cantal, and in the Vendée area (Deux Sèvres, Loire-Atlantique, Maine and Loire).

Mineral ore was processed in mills (8 in France) generally situated at the largest mining sites or by so-called "heap" leaching (static leaching). Their purpose was to extract and concentrate uranium:

- Bessines and Bernardan in Haute-Vienne
- Le Bosc in Hérault
- Gueugnon in Saône-et-Loire
- Bois-Noirs Limouzat in Loire

- Le Cellier in Lozère
- Saint-Pierre in Cantal
- Ecarpière bordering on Maine-et-Loire

The processing plant at Bouchet in the Essonne area can be added to these eight mills. However, the Bouchet mill represents a special case, since it is situated outside the mining areas and was built to develop processing methods and process foreign ores.

More basic processing methods for ores, limited to a leaching of ore in stockpiles on landscaped areas, were performed at nine other sites (see Figure 1).

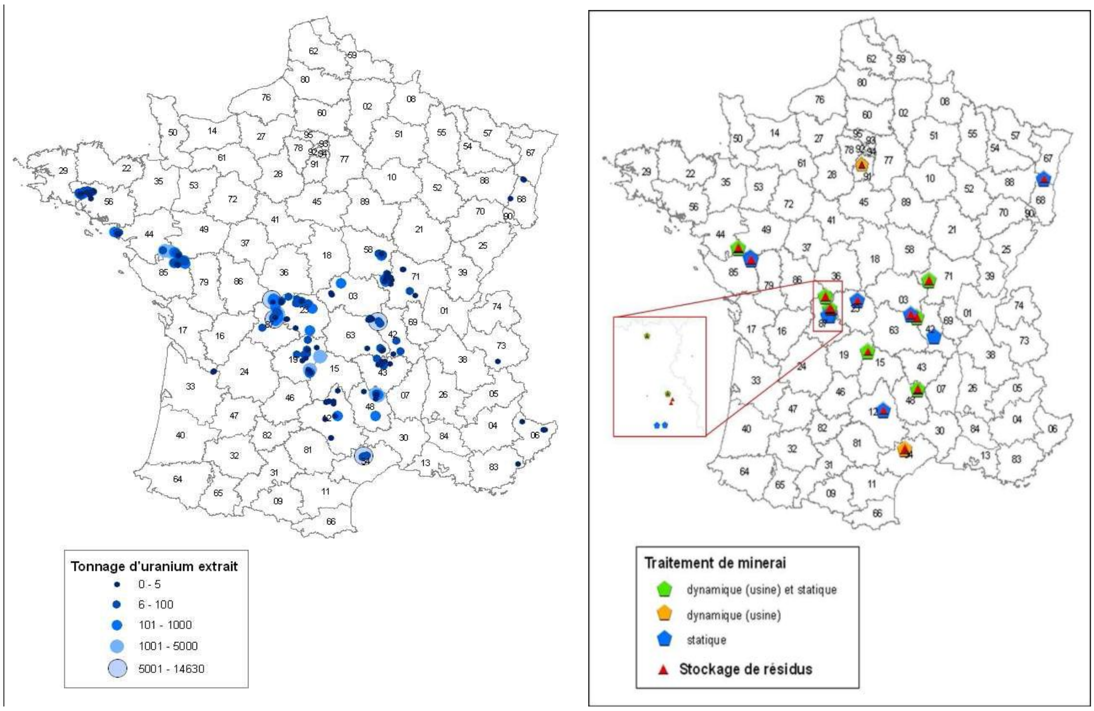


Figure 1: Location a) of uranium mining areas in France in relation to tonnage, and b) waste processing and storage sites. ©IRSN

Based on an analysis of the documents submitted, the team noted that, once separated from the tailings, the ore was crushed and chemically treated to extract the uranium. These industrial operations, which were regulated under the legislation on Classified Installations for Environmental Protection (ICPE), were performed either at a plant (referred to as dynamic leaching), or in heaps in designated areas (static leaching). After the processing operations, the uranium was recovered on one side (as a yellow powder known as “yellow cake”), and processing waste on the other.

Processing residue was stored in structures constructed on or near the treatment sites (17 structures distributed over 16 sites). These installations are managed under the legislation on Classified Installations for Environmental Protection (ICPE) under the heading No 1735:

- The eight sites mentioned above at which mills were operated;
- as well as the sites at Bellezane and Montmassacrot in Haute-Vienne, Bertholène in Aveyron, Rophin in the Puy de Dôme area, Ribière in La Creuse, La Commanderie bordering on the Vendée ares, and Deux-Sèvres and Teufelsloch in the Haut-Rhin.

Mining activities at the other sites was limited to the extraction of mineral ore. Depending on the characteristics of the deposits and the advanced techniques adopted, operations were conducted in open pit or underground mines. At smaller sites, operations were performed in trenches.

The acquisition of information on former uranium mines is an essential step in their management. Noting that knowledge of these former sites can currently be perfected, the Minister of State, the Minister for Ecology, Energy, Sustainable Development and the Sea, responsible for green technologies and climate negotiations, has asked AREVA NC to confirm, within three years, the environmental status of all sites for which it holds an administrative license or property deed. Within this framework, special attention should be given to sites that were previously not operated directly by AREVA NC, and sites at which waste products (other than mineral) may have been stored in the past.

Table 1 indicates levels of uranium content in different materials.

Table 1: Uranium content and levels of radioactivity classically associated with materials and waste present at mining sites

| | ***Uranium level (g/t)*** | ***Ra-226 activity (Bq/kg)*** | ***Total activity (Bq/kg)*** |
|---|---|---|---|
| ***Average for rock soils in France***** | A few g/t | A few tens | A few hundred |
| ***Granitic rock **** | A few tens g/t | A few hundred | A few thousand |
| ***Minerals*** | About one thousand g/t | A few tens of thousands | A few hundreds of thousands |
| ***Tailings*** | A few tens to hundreds of g/t | A few hundreds to thousands | A few thousands to tens of thousands |
| ***Residues*** | A few hundred g/t | A few tens of thousands | A few hundreds of thousands |

* excluding mineralisation
** average values for soil and rocks in France, whatever the geological context

**Quantities produced in France during the extraction period (1945-2001):**
Uranium production: 76 000 tonnes
Quantity of ore extracted: 52 million tonnes
Quantity of mining tailings produced as a result of mining extraction: around 200 million tonnes
Quantity of processing waste produced: 52 million tonnes

## 2.2 THE SITUATION IN THE REGION OF LIMOUSIN

Several sites operators, CEA-COGEMA (currently AREVA NC), *TOTAL*, *CFM*, *SCUMRA*, etc., operated uranium mines in the Limousin region, including 43 open-cast mines (OCM) and 25 underground mine workings (UMW) for a period of about fifty years. In producing

36 000 tonnes of uranium (out of 76 000 tonnes at a national level), these operators extracted 70 million tonnes of uranium ore.

Today, AREVA NC is the sole operator responsible for the radiological monitoring of these former uranium sites in the Limousin region.

## 2.3 SOURCES OF EXPOSURE TO RADIATION ASSOCIATED WITH FORMER URANIUM MINES

Former uranium mining sites can be responsible for specific exposure to ionizing radiation, due to uranium levels in materials and waste products, as well as the presence of radionuclides descending from uranium. Of course, these substances were already present in the minerals and rocks before their extraction from the ground, and no new radioactive products have been added from mining activities.

On mine sites or in their immediate periphery, mining tailings and, where applicable, residue stored on site, are the primary sources of exposure to radioactive substances. More localised areas of contamination, which are generally well identified, can appear in addition to these sources, resulting specifically from the spillage of materials or residues from various operations at the sites: around factories and loading areas along routes used to transport the waste from a processing plant to a storage site, and in settling ponds or water treatment stations. Given the presence of human activities on or adjacent to these former mining sites, people may be exposed to these sources of radioactivity, at least occasionally. In particular, situations that warrant the most attention are those related to the construction of buildings and residences in areas with untreated contamination points during the redevelopment of a mine site. The possibility of encountering situations such as these is higher for sites that have been more actively exploited (mining with extraction of large tonnages of ore, and/or the presence of a processing mill) and situated in the vicinity of cities or towns.

However, the verification team has noted that mining activity has changed the physical state of uranium and radioactive substances originally present underground, thus resulting in an increased risk of environmental spillage and human exposure, even after the cessation of mining.

The following conditions can generally be found at former uranium mining sites:

- Localised increase in radioactivity and concentrations of radon (radioactive gas) in the air, from tailings deposited on the surface, and for some sites, the storage of processing residue, with levels of radionuclides above the average values usually present on the surface. People who find themselves in an area containing such materials are subject to increased exposure, due to ambient radiation emitted by the soil or the inhalation of radon in the air. If uranium and other associated radioactive substances are contained in fine, loose materials (sand, clay, etc.), a risk may also exist of exposure from the involuntary ingestion of particles, and even by the inhalation of resuspended dust in the air; however, barring particular and exceptional conditions, these pathways are negligible;

- An increase in uranium and radium concentrations in surface waters and sediments, resulting from the dissolution of constituents from materials stored on the surface by rainwater or runoff, as well as drainage from flooded tunnels. This phenomenon, which naturally affects rocks and minerals even before any industrial activities, is enhanced within a mining context since:

1. the disposal of these materials on the surface favours their exposure to meteoric water;
2. the physical characteristics of the materials have been modified by mining operations (effects of crushing, grinding, etc.), thus favouring the circulation and action of water on the materials.

At certain sites, the characteristics of the water collected require treatment before being discharged to the environment. Several water treatment stations are still being operated by AREVA NC. In spite of these treatments, water discharges out of some sites may lead to an increase in radioactivity in rivers downstream, and the deposition of sediments containing radioactive substances at the bottom of lakes or on the banks.

### 2.3.1 Sources of exposure related to the reuse of tailings

Mine tailings were transported to remote mine sites for use as backfill, earthwork or as a road base. Rock excavated to access the ore, being of no use for the mine operator, constitutes a recoverable and easy to access material for public works contractors and quarry operators. Many cases of tailings disposal or exploitation of rock piles are listed on uranium mining sites. The reuse of tailings creates surface areas with a higher natural background radiation than the local level, such as along roads or paths, in roadways on farms, on serviced platforms, etc.

The above situation warrants the most attention in terms of human exposure. In fact, in addition to increasing the level of external exposure to gamma radiation emitted by mine tailings, their decay produces radon, a radioactive gas that can be transferred from underground to buildings. Depending on building specifications and their use and occupation, radon can accumulate in certain parts of buildings and reach high concentrations. In this situation, the occupants may be highly exposed to this gas, and their descendants will be exposed to radiation; of course, the extent of this exposure depends on the amount of time occupants reside in the affected buildings. Awareness of risks associated with the reusing of tailings has led to the gradual implementation of tighter controls on the transfer of these materials. A procedure was implemented by COGEMA in 1984. It stipulated the following:

- the keeping of a register of transfers and their recipients;
- a commitment on the part of the beneficiaries not to make use of the tailings as a base in the construction of buildings;
- dosage rates of gamma radiation rose from 500 to more than 1000 nSv/h, with higher values locally, and natural background radiation in the order of 100 to 300 nSv/h.
- a limit of 100 ppm for uranium levels of disposed tailings.

With the amendment of mining regulations in 1990, a provision imposing the implementation of a management plan was introduced in the General Regulations for Extractive Industries (RGIE) for all materials exceeding 300 ppm, thus highlighting the potential risk they could represent.

The current priority is to identify areas affected by the reuse of tailings, specify exposure risks, and, if necessary, initiate actions to reduce exposure levels where they are significant. The reuse of mine tailings regards only 1 to 2% of extracted tailings.

In all cases, it is important to preserve an archive of the presence of these tailings to prevent later developments (construction of buildings in particular) from generating new risks of exposure. In addition, measures should be taken to ensure that tailings stored at sites are not used without special precautions. Several cases of exposure or plans to make use of rock piles are still listed on former mining sites (in Limousin and Vendée in particular).

Similar precautionary measures should also be applied to any use of quarry materials in those sectors affected by exploration or mining, since the geological environment in these areas is conducive to the natural presence of high concentrations of uranium in extracted rocks. Currently, the use of materials is subject to authorisation by the Prefect, who sets operating requirements.

### 2.3.2 Sources of exposure related to the storage of waste

Once separated from the tailings, the ore was crushed and chemically treated to extract the uranium. These industrial operations were carried out either at a plant (referred to as dynamic leaching), or in heaps in designated areas (static leaching). After the processing operations, the uranium was recovered on one side (as a yellow powder known as “yellow cake”), and processing waste on the other.

For processing operations involving dynamic leaching, the waste would be in the form of a pulp with small particles. The particle size of static residues is much coarser.

Contrary to mine tailings, processing waste is an industrial waste which differs from the initial rock in its physical modifications (grinding) and mineralogical alterations induced by chemical treatments. If the residues are depleted in uranium in relation to the ores, their level of radioactivity is less than that of the ore because of the presence of all radioactive products descending from uranium, of which radium-226, in particular, remains identical to the level contained in the ore. Radium-226 activity is ordinarily in the order of a few tens of thousands of Bq/kg, whereas total activity, all radionuclides combined, is in the order of several hundreds of thousands of Bq/kg. In this respect, these residues are similar to radioactive waste from low to very low activity and long-lived.

The quantity of waste stored in France can be estimated at 50 million tonnes in total. Waste is stored at 16 sites. Note that they are close to VLA (very low activity) waste and LA (low activity) waste in some cases. Two types of ore processing residues exist, and they do not exhibit the same activity concentrations.

Storage sites for mining tailings were set up in the vicinity of uranium ore processing installations. These sites, measuring one to tens of hectares, hold a few thousand to several million tonnes of waste. Figure 2 below shows exposure pathways to sources of radioactivity on a storage site that has been "relieved" of such waste.

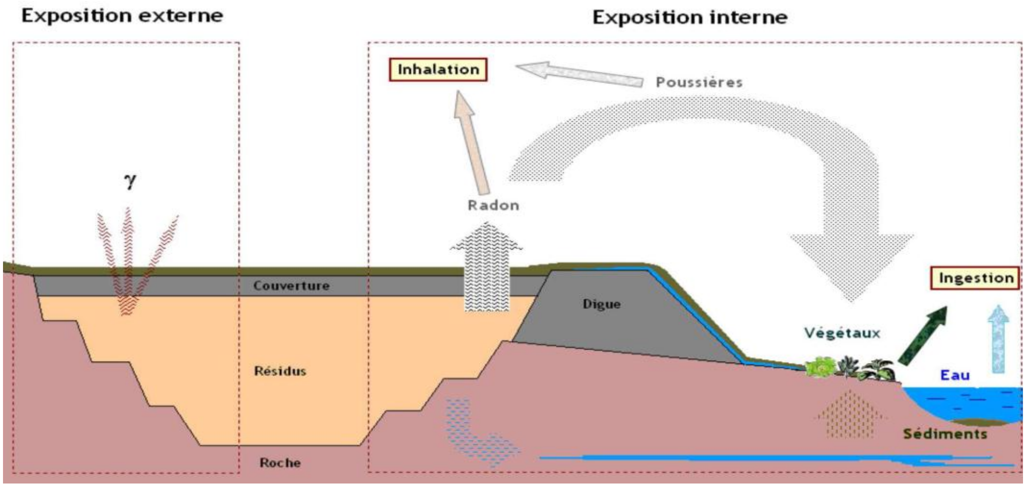


Figure 2: Exposure pathways to sources of radioactivity at former uranium mining sites (for a site storing processing tailings) ©IRSN

### 2.3.3 Sources of exposure related to the transfer of radioactive substances in water and sediment contamination downstream of mining sites

The team took note that water flowing through the mine tailings or processing waste, as well as water flowing from old flooded workings can cause a transfer of radioactive substances (uranium and radium in particular) to waterways downstream. In several cases, it has been indicated that this transfer could lead to an accumulation of radioactive products (particularly uranium) in the sediments of bodies of water. This situation has been particularly flagged up in Haute-Vienne, in the Lac du Saint-Pardoux (used as a body of water for recreational purposes) and in the Crouzille pond (used as a reserve for providing water to the city of Limoges). In both cases, concentrations detected in the sediment reached values exceeding 10000 Bq/kg in uranium-238, whereas levels measured in sediment in waterways in the regions concerned are generally lower than 1000 Bq/kg. Concentrations of radioactive substances measured at the same points in the water system remain at comparable levels to the levels normally found in these regions. In both cases alluded to above, dredging operations and the removal of sediment were implemented by AREVA NC when emptying out the water bodies. For mining sites where radioactive substances have been transferred to the water, leading to accumulations, opportunities should be explored to limit the intake of uranium from these sites in order to avoid further accumulation. Further action consists in verifying the lack of impact on aquatic ecosystems associated with these accumulations of uranium in sediments. Available assessments already exclude any significant impact on the public.

## 3. REGULATORY AUTHORITIES - OPERATOR

France has over 210 old uranium mines, with 16 uranium extraction waste storage sites. For many years, these mines have been subject to special attention from the public authorities, notably the Radiation Protection and Nuclear Safety Mission (MSNR), the Ministry of Ecology, Energy, Sustainable Development and the Sea (MEEDDM), and the Nuclear Safety

Authority (ASN), all of whom consider that these sites should be part of a monitoring process and, where appropriate, to a restoration process aimed at limiting their impact on public health and environmental quality.

## 3.1 LEGAL REGULATIONS

### 3.1.1 Introduction

Environmental monitoring around these mining sites is governed by the provisions of the Mining Code for old extraction sites (version 2001 + radioactivity; in this version the threshold for public exposure, due to mining activity, has been lowered from 5 mSv/year to 1 mSv/year) supplemented by the General Regulations for Extractive Industries (RGIE), the Environmental Code (Title 1 of Part V relative to facilities classified for environmental protection purposes) specifically in the case of classified facilities for the storage of uranium ore processing waste (Section 1735 of the nomenclature), and finally by the Public Health Code in relation to radiation exposure.

The following articles of the Public Health Code apply:

- Art. L1333-1: 3 basic principles for nuclear activities: justification, optimisation and limitation;
- Art. R 1333-8: The sum of effective doses received by the public from nuclear activity must be kept below 1 mSv/year;
- Art. R1333-77, R1333- 78, R1333-89 à R1333-92: Management of extended exposure to radiation from past nuclear activity;
- Art. R4451-1: Applicable to workers at nuclear facilities who may be at risk due to ionizing radiation.

### 3.1.2 The current legal situation

#### 3.1.2.1 The Planning Act on the sustainable management of radioactive materials and waste No 2006-739

Although all mining activities regarding uranium have ceased in France, technical and administrative developments regularly occur at certain sites listed with MIMAUSA. This is the case for works being conducted to complete reinstatement conditions at particular sectors or relating to studies requested by the administration, local population or certain associations.

It is also the result of the changing regulatory framework the sites and facilities they host are subject to. Since the first version of the MIMAUSA inventory, changes and developments have been implemented in the field of radioactive waste management, the regulation of classified facilities, and the prevention of mining risks.

On 28 June 2006, a Planning Act was enacted on the sustainable management of radioactive waste and materials. This law has provided a comprehensive and coherent legislative framework for all materials such as spent fuel, radioactive waste, waste enhanced natural radioactivity and waste from former uranium mines.

The 28 June 2006 legislation provides for the adoption every 3 years of a national plan for the management of radioactive waste and materials (PNGMDR). This plan must provide a clear framework for all radioactive waste. The first PNGMDR was established by the government. It includes a section pertaining to the storage of uranium tailings.

Article 4 of the legislation of 28 June 2006 mentions that the storage of tailings from former mining facilities and the processing of uranium ores, which are governed by Title 1, Part V of the Environmental Code, must be subject to an intensified monitoring plan.

For this purpose, the operator of these facilities (AREVA NC) had to submit a study to the government before 31 December 2008 on the impact of these storage sites on health and the environment, giving details, if necessary, of the measures planned to strengthen the provisions to prevent the risk of exposure for the public.

The 28 June 2006 legislation also establishes a clear legal framework to secure the necessary funds for decommissioning and radioactive waste management, consolidating missions conducted by ANDRA (National Agency for Radioactive Waste Management), including a public service mission to rehabilitate sites contaminated by radioactive waste and to reclaim waste from a faulty operator.

#### 3.1.2.2 Revision of the nomenclature for classified facilities

While uranium mines and their dependencies are covered by the Mining Code, mine tailings storage sites are classified facilities for environmental protection purposes.

Until 2006, mine tailings storage sites either fell within section 167 of the nomenclature for classified facilities (industrial waste from classified facilities) or section 1711 of the nomenclature (deposit or storage of radioactive substances in the form of non-sealed sources).

To make the administrative provisions applicable to the storage of uranium tailings more easy to understand, the Ministry of Ecology, Energy, Sustainable Development and the Sea (MEEDDM) decided to combine all of these activities in a dedicated section of the nomenclature of classified facilities.

The purpose of this section is to better take into account:

- the specificity of these radioactive storage sites, which must not be confused with conventional landfills;

- the quality of these storage sites in “real-estate” terms, as they can represent several million tonnes of raw material.

Hence, Legislative Decree No 2006-1454 of 24 November 2006 created a section 1735 which is entitled: "Radioactive substances (deposition, stockpiling or storage) as a solid residue of uranium ore, thorium or radium, and their processing products not containing uranium enriched with the isotope 235, the total quantity of which exceeds 1 tonne."

Facilities under this section of the nomenclature are routinely subjected to administrative authorisation.

#### 3.1.2.3 Prevention plans for mining risks (Article 94 of the Mining Code)

The Prevention Plan for Mining Risks (PPRM), introduced by Act of 30 March 1999, is a tool for managing the development of municipalities affected by the residual effects of former mining operations. The PPRM is used when mining hazards exist over large areas, in urban areas or areas targeted for development projects. It is prescribed by the prefect, after mining operations have ceased, in municipalities in which mining hazards are believed to exist. Following approval, it is appended to the local development plan and acts as a public utility easement.

Hazards to be taken into consideration are ground settling, landslides, subsidence, floods, earthfalls, mine gas emissions, water or soil pollution, ionizing radiation, and combustion of waste dumps.

The PPRM includes a definition of mining hazards (nature, importance, probability and consequences), a study of surface issues (housing, road infrastructure, commercial and industrial facilities) and the mapping of areas deemed high, medium or low risk. Twenty-four PPRMs have been prescribed since 2002. Five PPRMs are approved; three in Moselle and two in Meurthe-et-Moselle. Several dozen PPRMs are due to be prescribed by 2010. The majority of non-approved prescribed PPRMs are in the mapping phase of hazardous areas.

A PPRM defines building regulations for each area. A procedural guide for developing PPRMs in relation to the risk of landslides, flooding and the emission of mine gases was produced by the National Institute for Industrial Environments and Risks (INERIS) at the request of the Ministry of Economy, Finance and Industry (MINEFI) in May 2006.

A circular on the development of PPRMs defining building conditions in areas with mining hazards will shortly be signed by the ministers responsible for industry and urban planning. It will take into consideration the feedback provided by the initial PPRMs.

## 3.2 ADMINISTRATIVE STRUCTURES, SUPPORT BODY AND PLURALISTIC EXPERTISE GROUP

### 3.2.1 Introduction

In France, the following primary governmental structures are involved in the organisation and control of radiation monitoring at former uranium sites:

- The Ministry of Ecology, Energy, Sustainable Development and the Sea (MEEDDM), and more specifically, its Radiation Protection and Nuclear Safety Mission (MSNR) and Regional Directorates for the Environment and Spatial Planning and Housing (DREAL)
- The Prefectures in the departments concerned
- The Nuclear Safety Authority (ASN)

These administrative structures are underpinned by various support structures, in particular, the Institute for Radiological Protection and Nuclear Safety (IRSN)

In addition, a pluralistic expertise group (GEP) was set up in 2006: GEP - LIMOUSIN

### 3.2.2 Ministry of Ecology, Energy, Sustainable Development and the Sea (MEEDDM) - Radiation Protection and Nuclear Safety Mission (MSNR)

The Ministry of Ecology, Energy, Sustainable Development and the Sea (MEEDDM) is a ministry of the French national government created by the Legislative Decree of 18 May 2007 through the merger of two ministries (the Ministry of Ecology and Sustainable Development and the Ministry of Transport, Installations, Tourism and the Sea), as well as the annexation of the part of the Ministry of Industry which deals with energy matters. The Ministry’s current name dates back to the re-organisation of 23 June 2009. It was previously known as the Ministry of Ecology, Sustainable Development and Spatial Planning (MEDAD), then the Ministry of Ecology, Energy, Sustainable Development and Territorial Planning (MEEDDAT).

MEEDDM has six major directorates.

The Directorate General for Energy and Climate (DGEC) defines French policies for energy- and climate-related issues and is responsible for setting policy direction for the supply of energy including renewable energy and the security of supplies. It must also elaborate policies to control energy demand and emissions of greenhouse gases, for instance, by jointly establishing the quality of fuels. In addition, the DGEC is responsible for establishing policies to combat atmospheric pollution, as well as setting policies adapting to climate change.

For its part, the Directorate General for Infrastructure, Transport and the Sea (DGITM) is responsible for defining a universal, cross-cutting transportation policy. It is responsible for the “all-around” programming of infrastructures and must encourage modal shifts and ensure the proper management and maintenance of the corresponding holdings and heritage. The DGITM is also responsible for implementing appropriate economic regulatory measures in this sector, and transportation services for people and goods, while guaranteeing the safety of infrastructure.

A specific directorate is dedicated to civil aviation (DGAC) and for managing all aviation-related issues. As such, it is responsible for infrastructure, the industry’s economic regulation, air navigation, control and safety.

A fourth directorate is responsible for planning, housing and nature (DGALN). Consequently, it develops, coordinates and evaluates policies relating to urban planning, construction, housing, landscape, biodiversity, water and non-energy commodities. It oversees their implementation status over land and marine areas, ensuring consistency nationwide, while managing resources rationally and in a balanced manner.

The Directorate General for Risk Prevention (DGPR), to which the MSNR is attached, is for its part responsible for coordinating the prevention of all types of risks and ensuring that they are dealt with in a more consistent manner. It is responsible for the prevention of natural risks and manages all water-related risks in order to facilitate an integrated approach to flooding risks, bringing together the departments responsible for weather warning, flood prevention and water management safety. Furthermore, it must promote greater consideration for issues related to emerging risks, and thus prepares the ministry’s contribution to health policy where the latter is also related to the environment.

Finally, one last directorate is specifically dedicated to road and traffic safety (DSCR). It elaborates and implements road safety policies and assists inter-ministerial actions conducted in this area.

**Regional services** under MEEDDM

- For each region, with the exception of Île-de-France and the overseas regions, the Regional Directorates for the Environment and Spatial Planning and Housing (DREAL) which replace, since 3 March 2009 for the former, and since 1 January 2010 for the others, the 26 Regional Directorates for Facilities (DRE), as well as the 26 Regional Directorates for the Environment DIREN), and the 26 Regional Directorates for Industry, Research and the Environment (DRIRE).
- In Île-de-France, the regional and interdepartmental directorate for accommodation and housing, the regional and interdepartmental directorate for facilities and housing, and the regional and interdepartmental directorate for environment and energy participate in the implementation of activities within the scope of MEEDDM.
- In the overseas regions, there are the Regional Directorates for Facilities (DRE), Regional Directorates for the Environment (DIREN), and Regional Directorates for Industry, Research and the Environment (DRIRE).

The Radiation Protection and Nuclear Safety Mission (MSNR) of the Ministry of Ecology, Energy, Sustainable Development and the Sea (MEEDDM) participates in state missions on issues related to nuclear safety and radioprotection. In particular, it:

- proposes and backs up the government's policies on former uranium mines
- follows radioactivity issues related to facilities classified for environmental protection purposes, under the legislation on classified facilities, and proposes measures and regulations in this area.

#### 3.2.2.1 Regional Directorates for the Environment and Spatial Planning and Housing (DREAL)

Prefectural orders are applied under the mining and environment codes throughout the lifetime of these sites, including in regulating their rehabilitation and monitoring. The monitoring of these sites is ensured in both cases (mining and environment codes) by inspectors from the Regional Directorates for the Environment and Spatial Planning and Housing (DREAL), under the authority of the prefects for the Minister of Ecology, Energy, Sustainable Development and the Sea (MEEDDM).

The DREALs currently ensure four types of missions:

The network of DREALs exercises this mission under the authority of MEEDDM. Concerning active mining facilities, the DREALs oversee not just the respect of measures for the prevention of environmental risks and pollution, including the comprehensive redevelopment of sites operated, but also inspect work operations and monitor the safety of workers at mines and quarries. Furthermore, the DREALs oversee the control of risks and impacts associated with the closure of old mining facilities (post-mining), as the state is responsible for the prevention and treatment of risks associated with safety for the public and property, in the event of a waiver of mining claims, loss or failure of the operator. Finally, the DREALs handle procedures relative to mining claims and monitor the application of the Mining Code.

For the purposes of radiation protection and in collaboration with the DREALs, the Nuclear Safety Authority (ASN) participates in the monitoring of former mining sites (the ASN provides support to the DREALs).

As regards quarries, the DREALs normally steer the operations for establishing departmental plans for quarries, together with the Departmental Commissions for quarries, which are subsequently approved by the Prefects.

### 3.2.3 Departmental Prefectures

As an administrative area, a prefecture covers a territory that is absolutely identical to the department in which a prefect is appointed. In everyday language, the chief town in a department is often referred to as the "prefecture".

A department is itself subdivided into several sub-prefectures, which always correspond to a district. The prefect oversees all districts in the department. The secretary general of the prefecture is also the sub-prefect of the district town. Other districts are each headed by a sub-prefect who has his/her seat at the level of the sub-prefecture or town district.

Administrative services within a prefecture are organised in an almost similar manner in each department. This administration, whose objectives and means differ from those of the general councils of the departments, is based in one or more buildings sometimes known as the "hôtel de prefecture”. This is where a prefect in office is necessarily based.

Tasks performed by department prefectures include:

- issuing identity documents, passports, vehicle registration documents, driver's licences
- managing residence permits for foreigners
- monitoring the legality of documents issued by local authorities
- providing inter-ministerial coordination for the state’s decentralised services
- managing European funds
- providing civil protection and safety
- organising elections.

In their circular of 22 July 2009 (Annex 3) the Ministry of Ecology, Energy, Sustainable Development and the Sea (MEEDDM) and the Nuclear Safety Authority (ASN) asked the prefects of the departments concerned to implement a series of actions (by means of decrees) relating to the monitoring of former uranium mining sites in France.

### 3.2.4 The Nuclear Safety Authority (ASN)

An independent administrative authority created by the law of June 13 2006 on transparency and safety in nuclear and related issues, the Nuclear Safety Authority (ASN) is responsible for supervising civilian nuclear activities and radiation protection in France. On behalf of the state, it monitors nuclear safety and radiation protection in France to protect workers, patients, the general public and the environment from risks associated with the use of nuclear energy. Its task is also to help inform citizens.

The ASN is administered by a panel of five commissioners, including its president.

The directorate general of the ASN ensures the implementation of guidelines set by the ASN and by its board.

The directorate general administers the daily activities of the ASN and focuses on the effectiveness of its actions through:

- the central services situated in Paris and Fontenay-aux-Roses;
- the ASN's 11 territorial delegations situated in Bordeaux, Caen, Châlons-en-Champagne, Dijon, Douai, Lyon, Marseille, Nantes, Orléans, Paris and Strasbourg, which exercise their monitoring activities under the authority of a territorial delegate, and participate in all missions conducted by the ASN in their respective territories.

Under the law on transparency and safety in the nuclear sector, in matters related to the environment the ASN is specifically charged with:

- organising permanent monitoring for radiation protection, including the monitoring of environmental radiation throughout the country;
- authorising and monitoring discharges of gaseous and liquid effluents and waste from nuclear facilities;
- proposing, coordinating and implementing regulatory and control policies on the environmental monitoring of nuclear sites;
- issuing licences[3] to laboratories measuring radioactivity in the environment.

On environmental issues, the ASN's actions are primarily oriented towards three areas:

- preventing and reducing risks and hazards arising from the operation of basic nuclear installations, with the aim of protecting public health and safety, nature and the environment, and property;
- limiting the spread of radioactivity and toxic substances from the nuclear industry to the environment through the strict regulation of effluent discharges and waste;
- managing the monitoring of radioactivity in the environment with a view to informing the public about the health impacts of nuclear power in France and levels of radiation in the environment.

The ASN focuses on former mining sites in several ways:

- Waste management in the long term especially within the framework of the National Plan for the Management of Radioactive Waste and Materials (PNGMDR)
- Radiation protection
- Monitoring the environment

[3] Licences are necessary for the acceptance of radioactivity measurement results within the national measurements network. Licences are granted by the ASN, notably following the laboratory's participation in inter-comparison tests organised by the IRSN. Licences are currently valid for four years.

Under the radiation protection framework and in collaboration with the DREALs, the ASN participates in the monitoring of former mining sites

- The ASN divisions act as a support for the DREALs

### 3.2.5 The Institute for Radiological Protection and Nuclear Safety (IRSN)

The Institute for Radiological Protection and Nuclear Safety (IRSN), which was set up by the law on AFSSET and decree No 2002-254 of 22 February 2002, is a public, industrial and commercial body, under the joint supervision of the ministers of defence, the environment, industry, research and health. The IRSN combines over 1500 experts and researchers from the Institute of Nuclear Safety and Protection (IPSN) and the office for protection against ionizing radiation, who are competent in nuclear safety and radiation protection as well as in the monitoring of nuclear and sensitive materials. The Institute’s missions, as defined in decree No 2002-254 of 22 February 2002, the inter-ministerial directive of 7 April 2005 and by the decree of 27 June 2005, include the following broad categories:

1 - Support missions to the government, in the following areas:

- the safety of nuclear facilities and transportation of radioactive and fissile materials, including protection against malicious acts;
- protection of the environment, workers, and the general public regarding exposure to radioactivity;
- the safety and control of nuclear materials.

The goal is to contribute to the development of regulations, standards or other implementation rules and technical jurisprudence, providing expert advice on measures taken by respective operators to control radiological risks, propose measures related to technical, health and medical issues in the event of an accident, contribute to crisis management and the implementation of emergency exercises, and provide an operational response capability.

2 - Missions attributed to the Institute in terms of its contribution to the radiological monitoring of the environment and the general public, in particular workers exposed to radiation, training them in radiation protection and managing the inventory of radioactive sources.

3 - Expertise, studies, measurements and research conducted on a contractual basis at the request of any agency, whether French or foreign, calling on the Institute’s scientific and technical expertise.

4 - The definition and implementation, within the Institute or in partnerships, of research programmes and studies required to sustainably guarantee that the Institute’s expertise rests on the best scientific knowledge, reducing uncertainty in the assessment of risks deriving from existing or proposed technologies.

Moreover, in all its fields of expertise, the Institute must also contribute to providing information to the public.

On behalf of MEEDDM, the IRSN provides technical support missions in relation to former uranium mines.

On behalf of the ASN, the IRSN provides opinions on matters relating to the long-term impact of mining waste management and issues relating to radiation protection.

In France, the IRSN ensures the monitoring of radioactivity levels throughout the country.

### 3.2.6 Pluralistic Expertise Group (GEP) - Limousin

Created by the ministers responsible for the environment, industry and health, the pluralistic expertise group (GEP) on uranium mining sites in the Limousin region fulfils a broad and ambitious mission. Established in June 2006, this group must, from a critical inventory of the situation at former sites in the mining division of Crouzille, propose to government possible improvements in relation to long-term monitoring and management and, if necessary, identify appropriate actions allowing for a reduction in current impacts. More than 24 sites spread over 7 watersheds in total are subject to the group's expertise.

To provide a basis for these initial observations, the GEP has at its disposal a reference document prepared by AREVA NC at the request of the Prefect of Haute-Vienne: the Decennial Environmental Report (BDE). This document is itself the subject of a comprehensive critical analysis conducted by the IRSN, which is steered with the support of the GEP.

The GEP's mission mobilises close to 30 experts who bring their expertise in earth sciences, mining, the measurement of radioactivity in the environment, radioprotection, epidemiology and the evaluation of impacts on the environment, as well as specialists in other fields of interest, such as, for example, environmental law. Another feature of the group's composition is its plurality and willingness to take into account all sensitivities and available sources of information. The GEP members are thus representatives of public bodies in France – first and foremost the IRSN, as well as GEODERIS, InVS and INERIS – university laboratories, representatives of local and national associations, independent experts, industrial representatives of AREVA NC, and foreign experts.

As explicitly requested by the ministers, within the framework of its missions the group provides information to the authorities and to the public. It is thus obliged to illustrate the progress of its work before exponents of the media and consultation groups established in each respective geographic area.

## 3.3 "THE OPERATOR" AREVA NC –BESSINES[4] FACILITY

### 3.3.1 Situation within the AREVA NC Group

Based on the documents received, the verification team noted that AREVA NC is an industrial group specialising in all operations that make up the nuclear fuel cycle, from the extraction of natural uranium to spent fuel reprocessing and the recycling of reusable energy materials. Together with its subsidiaries and affiliates, it owns a large share of the global market for products and services related to nuclear energy.

Because of the specific processes involved, every step of the fuel cycle is an entire industry in itself. For this reason, the AREVA NC Group is operationally organised into 18 Business

[4] Until 2002 the Bessines facility was designated 'the Mining Division of La Crouzille'

Units ("BU"), grouped into five Business Groups corresponding to the fundamental steps in the nuclear fuel cycle:

1. The MINES Business Group comprises:
   - a Platforms division
   - a Support Functions division
   - an Operational Functions division, comprising 4 directorates (Directorate of Geosciences, Directorate of Projects, Directorate of Industrial Management, Directorate of Environmental and Corporate Responsibility).
2. the UPSTREAM Business Group (3 BU)
3. the REACTORS AND SERVICES Business Group (6 BU)
4. the DOWNSTREAM Business Group (5 BU)
5. the RENEWABLE ENERGIES Business Group (4 BU).

The Directorate of Environmental and Corporate Responsibility consists among others of the Directorate of Post-Mining Operations (DAM), which is responsible for monitoring and coordinating all activities related to the rehabilitation and monitoring of mining sites operated by the AREVA Group NC and currently shut down. It is also responsible for the Bessines facility, which manages sites in France (Limousin, Vendée, Hérault, Forez-Bourgogne), the company *COMUF* (Gabon), and subsidiaries in the United States (*CRI USA*, *PMC* and *COMIN*).

The Service of Process Studies and Analyses (SEPA) is a service that is hierarchically dependant on the Directorate of Technical Expertise and Services for the Directorate of Industrial Management within its Department of Treatment Plants and Processes. It is administratively part of the Bessines facility. SEPA consists of two geographically distinct units: the SPI/LAB testing and pilot sector, and the SAN analytical laboratory.

The flowchart for the Bessines facility is shown in Figure 3 below.

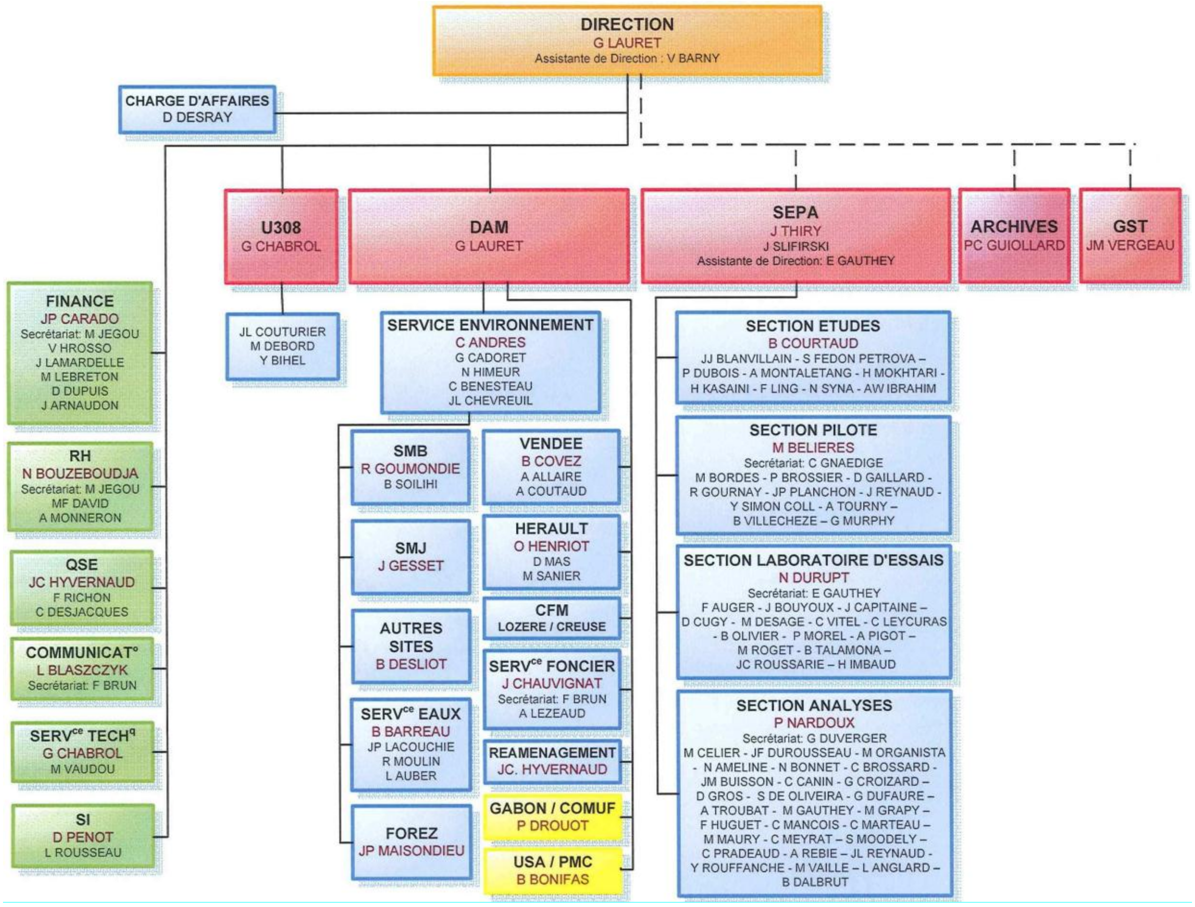


Figure 3: Flowchart of the AREVA facility at Bessines (©AREVA)

### 3.3.2 Activities exercised by AREVA NC services

#### 3.3.2.1 History

From 1948 to 1995, the Mining Division of La Crouzille operated a series of granitic uranium deposits which produced 23 324 tonnes of uranium from 12 870 406 tonnes of ore at an average grade of 1.81‰.

The ore was mined in an open pit (OCM) for deposits close to the surface, and in underground mines (UMW) for deposits located at varying depths. The choice between these two types of operations depends on several technical and economic criteria, such as the geometry of the deposit, the ore grade and the tailings/ore ratio to be extracted.

Between 1958 and 1993, all of the extracted ore was processed at the Bessines-sur-Gartempe processing plant, which also received ore from other sources.

The total quantity processed amounts to:

- 14 839 000 tonnes of processed ore in dynamic conditions
- 8 614 000 tonnes of "pseudo-ore" (low-grade ore) of processed ore in static conditions

Following the shutdown of the Bessines facility in July 1993, the remaining ore was processed at the mining company's mill at Jouac, in Bernardan.

The sites were redeveloped according to the following general objectives:

- To ensure public safety and health on a permanent basis,
- To strive for the lowest possible residual environmental impact,
- To prevent any risk of inadvertent intrusions,
- To limit spaces with easements,
- To allow for the redevelopment of the sites as far as possible,
- To promote landscape integration,

In 1996, the Mining Division of La Crouzille was entrusted by the Business Group Mines with the surveillance and monitoring of all French sites whose mining operations had ceased.

In early 2002, the "Division minière de La Crouzille" [Mining Division of La Crouzille] became the "Etablissement de Bessines" [Bessines facility].

The sites are monitored by the Centre for Studies and Monitoring of Former Mining Activities (CESAAM), which in 2010 became the Post-Mining Authority (DAM).

Since 1 July 2002, the Bessines facility has managed the "Société des Mines du Bourneix" [Bourneix Mining Company], whose sites (former gold mines) have been redeveloped.

Since 1 January 2003, the Bessines facility has managed the "Société des Mines de Jouac" [Jouac Mining Company], whose mining sites have been redeveloped.

The Service of Process Studies and Analyses, SEPA, is located at the Industrial Site of Bessines-sur-Gartempe. This strategic Service is a mandatory step for all ore processing and uranium chemistry studies of the Business Group Mines. Its facilities date back to the 1960s, to the beginning of operations for the ore processing plant.

#### 3.3.2.2 Nature of activities at the Bessines facility

The team was informed that, within the framework of its mission to redevelop the sites, the facility had carried out demolition work, with significant movements of materials and landscaping, in an effort to remove visible traces of mining activities.

This work has been largely completed, as all mine workings between the bottom and surface have been made secure. However, various buildings must still be demolished and landslides from former works may still require backfill or remediation from the surface.

In the case of demolished buildings or equipment, materials which have been in contact with uranium products do not leave the site.

The monitoring of mining sites involves checking the stability of the soil, controlling impacts from past activities, and maintaining installations set up for the safety of people external to the facility.

The facility strictly applies the monitoring and controls stipulated by the regulations, through qualified personnel, procedures and operating methods for taking and preparing samples. Measurements outside its area of expertise are outsourced to qualified bodies, or if the administration has specifically requested that such measurements be conducted externally. It also ensures the operation of the water treatment stations. For the stability of the soil, regular monitoring and measurements are being conducted, as they have been requested by the administration.

For the safety of people outside the site, all gates, fences and warning signs must be checked and regularly maintained.

To fulfil its duties as landlord, the rivers are regularly maintained according to local customs when they cross plots of land which belong to the facility.

The Service of Process Studies and Analyses (SEPA) of AREVA NC (Bessines facility) consists of four divisions:

- the Test Laboratory division (LAB), which primarily conducts tests for the development of ore treatment processes for the various deposits studied by AREVA NC, and for improving processes used within the AREVA NC facilities;
- the Industrial Steering division (SPI), which is responsible for the industrialisation of processes developed within the service or transmitted by companies within or outside the group;
- the Analysis division (SAN), which conducts all analyses inherent to the fields of inorganic or organic chemistry and radiation;
- the Studies division (SET), whose role is to ensure and develop the sustainable expertise of SEPA in relation to other divisions, leading the development and monitoring of business-type projects and R&D, based on the resources of the other three divisions, and providing reviews of internal technical designs.

The activities of the SPI, LAB and SET divisions are grouped together within the buildings situated in the northwest area of the site. The activities of the SAN divisions are situated in buildings at the northernmost area of the site.

The storage site for depleted uranium located in Bessines covers an area of 8 hectares situated in the northern part of the Bessines site. It comprises a transit facility containing a repackaging area, storage buildings built up as required (11 buildings planned at the end of the storage operations), roads providing access to the buildings, and a railway line connected to the SNCF rail network.

Depleted uranium is derived from the gas diffusion operations performed at the EURODIF plant at the Tricastin site (Rhone Valley). Exiting the plant as uranium hexafluoride, it is set in a stable solid form (or uranium sesquioxide U3O8) by the AREVA NC Pierrelatte. It is termed "depleted" (0.3%) since its grade of fissile uranium 235 (i.e. capable of producing energy) is lower than in its natural state (0.7%).

Depleted uranium oxide is packed in pseudo-cubic containers that are shipped by rail to their storage site in Bessines.

The Bessines site also comprises other AREVA NC services (primarily administrative: land management, archives).

# 4. PROBLEM ISSUES AT DECOMMISSIONED URANIUM SITES

## 4.1 RECLAIMING OLD MINING SITES

After the close of their operation, all sites were reclaimed in order to render them secure, reduce their radiological impact, and provide landscaping. Underground mines were partially backfilled and flooded. Access to the tunnels was closed off, and wells were sealed. Open-cast mining operations were either flooded, creating artificial lakes, or backfilled with waste rock or even used as storage sites for processing waste.

Most surface facilities (pit-head frames, crushers, concrete surfaces and various pools, workshops, factories, laboratories) were dismantled or demolished. Unlike the storage of tailings, all of which remain the property of AREVA NC, land rights for the numerous parcels occupied during the mining phase were returned to their original owners (mine operators generally acting solely as licensees). Land directly impacted by mining operations (including rock dump areas and open cast mining) have been returned to their original purpose or assigned to new uses. In numerous cases, the usage is agricultural (pastures and woodland in particular). The MIMAUSA database also lists other types of conversion:

- some buildings and land have been converted into industrial zones or taken over by municipalities to accommodate various types of facilities;
- quarries have been opened at some sites, in certain instances to operate piles of tailings;
- various types of landfills have been set up in open-cast mines;
- leisure activities (hunting grounds, hiking trails, shooting stands, motocross circuits) have been set up on some released land parcels;
- bodies of water created by the flooding of open-cast mines have been converted for recreational uses (recreational areas, fishing, diving) or for irrigation purposes.

During the proceedings that led to the changes in land use, some land parcels were subject to usage restrictions taking into account associated risks.

The mining and processing of uranium ores generated two types of materials or waste:

- tailings
- processing waste

Specific arrangements have been made at the sites to ensure their safety, and redevelop the landscape.

The team was informed that regulatory standards in France stipulate that residue (which, strictly speaking process waste products are) must not be confused with mine tailings, which are extracted along with the ore and comprise rocks that did not undergo any particular mechanical or chemical processes (as opposed to the ore).

## 4.2 MINE TAILINGS

The term ‘tailings’ designates barren rock excavated to access the ore. Nothing distinguishes tailings from rocks present in a given area, other than that their location in the vicinity of the mineralised areas means they are generally richer in uranium.

The team noted that tailings represent extremely significant volumes. The production of 1 tonne of ore generated on average 9 tonnes of tailings at open-cast mining sites, and 0.65 tonnes for underground mines; this resulted in a total production of 52 million tonnes of ore, and roughly 170 million tonnes of tailings generated in France.

Given the presence of uranium and its radioactive daughters, these tailings have a specific activity ranging from a few thousand Bq/kg up to several tens of thousands of Bq/kg.

Tailings have essentially remained at their production sites; they were stockpiled (in heaps) or used to fill open-cast mines and redevelop areas (particularly to cover process residue storage areas).

During mining operations, the sorting of tailings and ore was carried out by measuring the radioactivity of loads (bucket or dump trucks). Given the amounts involved, this sorting remained relatively coarse. Blocks of ore could well end up mixed in with tailings.

At the start of uranium mining operations, tailings were made available to local residents who might need materials for backfill. The verification team was informed that from 1 January 1984, COGEMA, in conjunction with the Central Service for Protection against Ionizing Radiation (SCPRI), established a transfer register to ensure better traceability of tailings from COGEMA sites.

However, these records give no indication of tailings reused before 1984, or originating from sites operated by companies outside the COGEMA group. The amendment of the Mining Code in 1990 laid down stricter rules for the management of materials from mining operations, requiring the establishment of a management plan for solids whose uranium content exceeds 0.03%.

In uranium mine environments, tailings were generally used as backfill. This practice was widely accepted. From 1984 onwards, however, rules were imposed on the operators of these mines to ensure the traceability of the places at which they were used. The team notes that, as of 1995, uranium mine operators definitively stopped this practice.

Once redeveloped, the ore extraction sites (outside the ore processing areas and processing residue storage areas) rarely cause health problems. Indeed, the natural radiological impact was thus lowered. However, it should be noted that some sites contain heaps of tailings which in some cases may require monitoring actions or special reclamation, or even easements allowing for the appropriate use of these sites.

Generally speaking, tailings reused in the environment are not considered to present health or environmental impacts (although this must be checked on a site by site basis). However, radon concentrations are also considered to exist in buildings erected on land on which tailings may have been used as backfill (or in their immediate vicinity). The action plan defined in the circular of 22 July 2009 also addresses this concern.

In addition, AREVA NC was requested to provide a generic modelling study of potential impacts to assess exposure from the use of mine tailings in the public domain.

The study delivered in late 2008 by AREVA NC considers four scenarios for the reuse of mine tailings (inert or selective) in the public domain (Annex 4); namely, roads, a farmyard, schoolyard, and an industrial building platform. These scenarios correspond to the most commonly reported cases of reuse of mine tailings and do not, on a first approach, exceed the addition of 1 mSv/year.

For the record, in relation to "nuclear activities", the regulatory value set by the public health code is 1 mSv/year added to natural radioactivity.

## 4.3 RESIDUES FROM MINING PROCESSES

Based on an analysis of the documents submitted, the team noted that, once separated from the tailings, the ore was crushed and chemically treated to extract the uranium. These industrial operations, which were regulated under the legislation on Classified Installations for Environmental Protection (ICPE), were performed either at a plant (referred to as dynamic leaching), or in heaps in designated areas (static leaching). After the processing operations, the uranium was recovered on one side (as a yellow powder known as “yellow cake”), and processing waste on the other.

For processing operations involving dynamic leaching, the waste would be in the form of a pulp with small particles. The particle size of static residues is much coarser. Contrary to mine tailings, processing waste is an industrial waste which differs from the initial rock in its physical modifications (grinding) and mineralogical alterations induced by chemical treatments. Although the residues are depleted in uranium in relation to the ore, their level of radioactivity is relatively significant due to the presence of all radioactive products descending from uranium, particularly radium-226. Radium-226 activity is ordinarily in the order of a few tens of thousands of Bq/kg, whereas total activity, all radionuclides combined, is in the order of several hundreds of thousands of Bq/kg. In this respect, these residues are similar to low to very low activity and long-lived radioactive waste.

The quantity of residues can be estimated at 50 million tonnes in total. The residues are stored at 16 sites. The team notes that they are VLA (very low activity) long-life waste products, and in some cases LA (low activity). Two types of ore processing residues exist, which do not exhibit the same activity concentrations.

- Low grade ore processing residues (in the order of 300 to 600 ppm of uranium) with an average total activity concentration of 44 Bq/g (of which around 4 Bq/g in radium-226). These residues, derived from static leaching (around 20 Mt) are either stored in heaps, open-cast mines, or used as an initial cover for dynamic processing residues;
- High grade ore processing residues (in the order of 1‰ to 1% uranium in French mines) with an average total activity concentration of 312 Bq/g (of which around 29 Bq/g in radium-226). These residues, derived from dynamic leaching (around 30 Mt) are either stored in old open-cast mines, sometimes with an additional dam, in basins closed off by a ring levee, or behind a dam blocking a thalweg.

Storage sites for mining tailings were set up in the vicinity of uranium ore processing installations. These sites, measuring one to tens of hectares, hold a few thousand to several million tonnes of residue.

The team was informed that the residues were redistributed and fenced off, and are currently being monitored by AREVA NC under the supervision of the DREALs. In particular, the rearrangement comprised the placement of a solid cover over the residues consisting of a layer of inert rock a few metres thick and a layer of topsoil to provide a geo-mechanical and radiological protective barrier. This coverage is primarily intended to prevent direct contact with the residues, provide an x-ray screen, and limit water infiltrations and the amount of radon in the air.

A monitoring device was established by analysing all pathways and exposure, and identifying population groups likely to be the most exposed group. The results respect the effective added dose limit of 1 mSv/year. This verification faces the practical difficulty of assessing the added dose received by the public, particularly in view of the natural radioactivity already present locally and the lack of a zero point at the opening of the mines. The concern to reduce the exposure level, required mainly under the principle of optimisation, is taken into account during the reclamation phase.

The team has taken note that from a regulatory standpoint the residues are considered industrial residues subject to the provisions stipulated in Title 1, Part V and in particular Article R 511-9 of the Environmental Code relating to facilities classified for environmental protection purposes. Most of the residues stored fall under section 1735 of the nomenclature of classified facilities.

Prior to the adoption of this regulatory standard, these storages were authorised by administrative acts under the Mining Code as dependencies of the mines.

With the progressive closure of mining sites, a series of actions were undertaken by the public authorities to define and implement a regulatory standard on the reclamation of storage sites. In 1986, a technical instructional note relating to uranium ore processing facilities defined applicable terms for the operation of these facilities. In 1993 the Barthélémy – Combes report entitled "Déchets faiblement radioactifs - 1ère partie : stockage de résidus de traitement de minerai d'uranium" [Low-level radioactive waste - Part 1: storage of uranium ore processing residues], compiled at the request of the Minister responsible for the environment, defined the goals and technical conditions for the reclamation of storage sites.

In December 1998, the Institute of Nuclear Safety and Protection (IPSN, succeeded by the IRSN) compiled a regulatory standard for the reclamation of storage residues. In 2001, the IPSN drew up the methodology for evaluating the radiological impact of stored residues from uranium ore processing, whereas the BRGM compiled the evaluation methodology for the stability of embankments surrounding certain residue disposal sites.

Finally, in 2003 the Ministry of the Ecology and Sustainable Development submitted to the IRSN the national inventory of uranium mining sites, "MIMAUSA" (Memory and Impact of Uranium Mining: Synthesis and Archive). An initial inventory was published in April 2004, later updated in September 2007.

In late 2008, pursuant to Article 4.5 of Law No 2006-739 of 28 June 2006 and Article 10 of its implementing decree No 2008-387 of 16 April 2008, AREVA NC submitted a study on the long-term impact on health and the environment of the storage of uranium tailings, a study assessing the effectiveness of embankments, a study on the characterisation of residues, and recommendations associated with these studies (folder 30 Jan. 2009).

The modelling methodology developed by AREVA NC to evaluate the dosimetric impact of long-term storage of residues displays a normal evolution scenario and four altered evolution scenarios including; a failure of the embankment and cover, the realisation of a habitat above the storage site with or without a cover, the construction of a road, and the presence of children playing on the excavated residues. This modelling is a significant development for assessing the impact of long-term storage of residues from uranium ores and is a first concrete application of the approach formalised by the circular of the Minister for the Environment of May 7, 1999 on the reclamation of uranium ore processing residues. The method developed is also consistent with the approach implemented for ANDRA surface storages, particularly through altered road construction or home building type scenarios for the stored residues.

This methodology was applied by AREVA NC at nine processing residue storage sites for ores of differing size and geological context. According to the results of studies conducted by AREVA NC, dosimetric impacts which may be received by the population under normal evolution remain below 1 mSv/year under active monitoring, whereas foreseeable results for assumptions of significant degradation of residue storages remain lower than a few tens of mSv/year.

The AREVA NC study also indicates that the residues evolve naturally toward a mineralogical and chemical form which greatly limits the mobility of uranium and radium. The assessment of the holding of the embankments conducted by AREVA NC is consistent with the methodological framework defined by the BRGM and indicates a good level of stability for the structures.

Moreover, following these studies and in accordance with commitments made by AREVA NC in its letter to the Minister of State (Ministry of Ecology, Energy, Sustainable Development and the Sea) dated 12 June 2009, AREVA NC maintains the monitoring of these sites and has started to consider replacing the water cover sheet at the Bois Noirs Limouzat site with a solid cover.

Moreover, the results of the studies and observations by the pluralistic expertise group on uranium mining sites in the Limousin region (Limousin GEP) are awaited. In fact, the Limousin GEP has sought to clarify the various operational and administrative functions involved in monitoring operations (knowledge acquisition, measurements, treatments, controls, application of easements, memory, etc.) and their necessary phasing in the short, medium and long term to ensure the control of sites. The final report of the work of the Limousin GEP expected in late 2010 should provide recommendations on long-term management prospects.

## 4.4 OVERFLOW WATER

The verification team has noted that some overflow water (from mines, tailing storage sites or residues) requires monitoring or treatment in order to precipitate radioactive elements held within it and thus meet discharge limits set in the operation permits. A marking of sediment can nonetheless be found downstream from the sites; it is linked to the quantities of uranium and radium emitted into the water system. It should be noted that French sites do not present significant problems of groundwater acidification, due to the mineralogical composition of deposits, and therefore do not pose major problems in terms of groundwater quality.

## 4.5 THE MANAGEMENT OF MINE TAILINGS AND RESIDUES AND OVERFLOW WATER

An analysis of the documentation received indicated to the verification team that the French authorities are requesting additional studies.

Hence, although the on-site management of tailings and ore processing residues is acceptable given the volume and characteristics of this type of waste, the long-term institutional monitoring and consequences of a possible future misuse of the lands in question should be studied more accurately. In fact, natural radionuclides present in mine residue have long lifetimes and emit gaseous radioactive daughters (radon).

AREVA NC must thus continue its studies on the long-term safety of mine residue and tailings storage sites, and on improving monitoring operations implemented at other former mining sites, relying in particular on the conclusions issued in late 2010 related to the GEP observations on the institutional long-term monitoring of storage sites for mine tailings.

It should be noted that the management of these former mining sites must comply with the action plan set out in the circular issued by the Ministry of Ecology, Energy, Sustainable Development and the Sea (MEEDDM) and ASN of 22 July 2009 (Annex 3), and the letter by AREVA NC dated 12 June 2009 addressed to the Minister of State (Annex 5).

> *The verification team supports the findings of the French authorities, who find that the operator must continue its studies on the long-term safety of storage sites for mine tailings, and on improving monitoring operations implemented at other former mining sites, relying in particular on the conclusions issued in late 2010 related to the GEP observations on the institutional long-term monitoring of storage sites for mine tailings.*

The verification team has noted that this action plan is structured around the following measures:

- Inspecting former mine sites
- Improving knowledge of impacts on the environment and health from old uranium mines and their monitoring
- Managing tailings: providing a better understanding of their uses and reducing impacts if necessary
- Intensifying information and consultation

The review provided by AREVA NC as part of the implementation of the national plan for the management of radioactive waste and materials (PNGMDR) is a critical step in the process of monitoring the safety of uranium ore residues. The documents submitted as part of this review currently allow for an assessment of existing knowledge on two key points: the characterisation of residues and the status of embankments surrounding certain storage sites. Note that the approach adopted by AREVA NC is consistent with the methodological framework defined by the BRGM, as requested by the Ministry for the Environment, for this type of storage. These documents also provide an initial indication of the foreseeable impacts with a normal storage site development scenario, and a range of scenarios for deteriorating developments. While the conclusions provided by AREVA NC form a credible basis for establishing the long-term safety of storage of uranium ore residues, further studies and analyses are nonetheless required to better justify and intensify the demonstration of long-term safety of residue storage sites. The main additions expected from AREVA NC are detailed below.

Regarding the long-term physical and chemical changes in ore processing residues, AREVA NC will have to continue to conduct specific studies using data obtained from the Brugeaud, Bellezane and Lodève sites, supplementing them and conducting a new sampling campaign at sites specifically selected for their relevance. The team was informed that AREVA NC will prepare geochemical models by end of 2012 based on the results obtained, in order to simulate various possible disturbances during the course of storage, analysing whether these results can be generalised to ore processing residue sites which have not been subjected to a specific on-site study.

Concerning the assessment of the status and holding of embankments surrounding the ore processing residue storage sites, AREVA NC must complete its geo-mechanical process evaluation by the end of 2011, specifying the requirements it intends to adopt in assessing the long-term safety of its storage facilities, including ensuring that consistency exists between the duration and stability of embankments and the frequency of the natural hazards taken into consideration, as well as possible effects on the works resulting from the stoppage of monitoring maintenance activities.

Regarding the assessment of the radiological impact of long-term storage of uranium processing residues, AREVA NC must make extensive use of the results of the dosimetric impact assessments conducted in 2008, on the one hand to verify their relevance to the measurement data it has on each site, and on the other to systematically identify opportunities to reduce the current and long-term impacts of ore processing residue storage sites on populations. To this effect, AREVA NC must evaluate, by the end of 2011, whether to intensify the quality of current coverings; in light of the evaluation results for long-term impacts, this appears to constitute a potentially effective solution at several sites, and its feasibility and appropriateness must be assessed for all ore processing residue storage sites.

AREVA NC must also seek to improve its knowledge base in relation to the movement of radon gas in the atmosphere from the storage sites to the surrounding environment, and the relevance of modelling calculations for the transfer of radon from a storage facility to a dwelling supposedly built above it in the event of a deteriorating development scenario.

Generally speaking, the studies commissioned by AREVA NC are recent and build on the measurements and observations conducted as part of the monitoring of the sites. It is necessary, nevertheless, to acquire data for a sufficient timeframe and on a representative number of sites. This research on long-term effects will therefore be spread out through to 2020, as assessments are made every three years together with the PNGMDR updates.

Some overflow water (from mines or tailing or residue storage sites) requires monitoring or treatment in order to precipitate radioactive elements within it and thus meet the discharge limits set in the operation permits.

## 4.6 RADIOLOGICAL AND ENVIRONMENTAL MONITORING OF FORMER URANIUM MINING SITES AND RESIDUE STORAGE SITES BY THE OPERATOR AND CONTROLS CONDUCTED BY THE AUTHORITIES

### 4.6.1 Introduction

The management of former uranium mines has been continuously monitored by the authorities since their closure. Following the securing of the mines, the management activities at these sites have gone on to include measures aimed at restoration, reclamation and monitoring.

The verification team notes that responsibility for the radiological monitoring of former uranium mines and storage sites containing mine tailings and uranium extraction residues lies with the operator (in the majority of cases with AREVA NC). Controls are performed by the competent authorities.

The operators, the managers of these sites, and the authorities must continue to act in a resolute manner. Thus, the Minister of State, the Minister for Ecology, Energy, Sustainable Development and the Sea responsible for green technologies and climate negotiations, has decided on the implementation of an action plan to:

- Better control former mining sites,
- Improve knowledge of impacts on the environment and health from old uranium mines and their monitoring,
- Managing tailings: providing a better understanding of their uses and reduce impacts, if necessary,
- Provide for more information and consultation.

The circular of 22 July 2009 (circular on the management of former uranium mines MSNR 2009-132; Annex 3), jointly drawn up by MEEDDM and the ASN and addressed to the prefects of the departments concerned, defines actions to be undertaken at the prefecture level on matters related to the monitoring of former sites of uranium operations in France. Based on prefectural ordinances, prefects require regular radiological surveillance by the mine operator.

The verification team has taken due note of this circular and acknowledges that the implementation of environmental reviews (which this action plan provides for) is the key tool in this approach. The plan will make it possible to study the behaviour of all former mines, to define improvement measures to be implemented to reduce their environmental impact and to re-evaluate the environmental monitoring of these mines in order to move towards a level of monitoring that is consistent with impacts and environmental issues.

As part of a public information policy, the verification team notes that the results of radiological monitoring, and generally the measurements in the areas around these mines, will each year be notified to the local information and monitoring committees (CLIS) and municipalities concerned.

### 4.6.2 Monitoring by the operator

As a rule, prefectural ordinances require the regular monitoring (by the operator) of the various known release points (upstream/downstream controls, location, output). At large sites or those with issues, the air (including radon), water and sediment are monitored around the plant sites. The operator can of course of its own initiative complement these regulatory checks with controls on specific points. Monitoring criteria are defined in the national network of measures.

Regulatory standards applicable to former uranium mine sites requires the environmental monitoring by AREVA NC of its sites by means of regular measurements. These measurements make it possible to verify compliance with regulatory requirements concerning emissions and to assess the impact of the sites on the environment and the public.

For sites storing mine tailings, monitoring is systematic and involves all pathways: water, air (ambient dose rate, concentration of radon in air and dust, products in the food chain). For other sites, monitoring depends on the kind of discharges (e.g. whether there is a water treatment station) and the specific situation at each site (water level, special purpose).

Regarding the long-term management of stored residues, beyond the 'classic' studies, Article 4 of the Planning Act No 2006-739 of 28 June 2006 on the sustainable management of radioactive waste and materials requires that a research and studies programme be established combining a review of the long-term impact of storage sites for uranium tailings with the implementation of a plan for enhanced radiation monitoring at these sites. This study must be incorporated into the National Plan for the Management of Radioactive Waste and Materials (PNGMDR).

In relation to the application of this article, in January 2009 AREVA NC presented a file involving three studies, dealing respectively with:

- the long-term impact of storage sites of uranium tailings on health and the environment
- an assessment of the status of embankments
- a characterisation of residues and their long-term evolution.

The evaluation of long-term impacts of sites is based on a dosimetric impact study which is the first application of the methodology recommended by regulatory standard *DPPR* 1999.

The monitoring of output rates, exposure to radon and dust radioactivity is carried out at stations located within the confines of the land sites and in residential areas considered most at risk. The results provided by these stations are representative of average exposure levels received by local residents. However, this monitoring does not detect areas of spot contamination, nor does it assess specific impacts.

The verification team observed that in its reply of 12 June 2009 (Annex 5) addressed to the Minister of State, the Minister for Ecology, Energy, Sustainable Development and the Sea, AREVA NC agrees to implement an action plan as part of this radiological monitoring of former uranium mines, tailings storage sites and uranium extraction residues.

The team also noted that AREVA NC was asked to post signs at its residue storage sites and mining sites under administrative supervision. These signs, which must properly cover the periphery of the sites, must provide information on the radiological monitoring carried out. During inspections conducted by the DREALs, inspectors will also ensure that these signs are maintained and continue to be posted.

### 4.6.3 Controls by the administration (authorities) and support structures

In the prefectures in France, and jointly with the Nuclear Safety Authority (ASN), the DREALs perform checks at the main mining sites identified in the MIMAUSA database. As part of this action, the 16 French residue storage sites are mandatorily inspected, as well as all sites that have operated processing plants or passive treatment platforms. Other sites may also be inspected because of their sensitive nature. Checks at sites listed in MIMAUSA as "small sites conducting research", "small sites conducting reconnaissance work" or "segmented", and at which no uranium was extracted have a lower priority.

Checks focus in particular on accesses, enclosures, the reuse of tailings, the requirements for environmental monitoring, the general status of sites, and containment devices; they include checking that arrangements designed, where necessary, to prohibit or limit access to the sites and limit their impact on health and the environment, are implemented in accordance with commitments made by AREVA NC (see Annex 5) and the requirements established by the prefectures.

The implementation of these actions can rely on the provisions of the Mining Code (see Article 77 et seq. of the Mining Code, particularly Article 79 which also applies when no exploratory activity has been carried out), the provisions of Article R512-31 of the Environmental Code for sites that fall under the regime of facilities classified for environmental protection purposes, and Title IV of Part V of the Environmental Code regarding tailings reused for embankments outside of the old mines.

In very special cases not covered by these regulatory tools, and in an absolutely exceptional manner, the provisions of Article L514-4 of the Environmental Code may be applied.

Moreover, given the specificities related to former uranium mines, the prefects (and DREAL) can rely on the services of the Nuclear Safety Authority (ASN) in the implementation of action plans, particularly in ensuring consistency with the principles of radioactive waste management.

In terms of expertise, the setting-up in 2006 of a pluralistic expertise group (GEP; see 3.2.7) should also be emphasised; the task of this group is to inform the public authorities about the management of mines that were once operated in the Limousin region (the main region affected by old uranium mines), and to take a critical look at the technical documents relating to the monitoring of these sites. The GEP must submit its findings in September 2010. Some of the results of this work will be extended to all former uranium mines.

Since the mine tailings are reused outside the perimeter of the old mines, the Minister of State has requested that they be surveyed, as stated in its circular dated 22 July 2009, identifying locations where land use is incompatible with the presence of these tailings, in order to be able to manage them.

This survey will primarily take the form of aerial mapping so as to indentify areas in which radiation exceeds background noise, due to the presence of such tailings. In 2009, 1 000 $km^2$ were thus surveyed from the air by AREVA NC. In 2010, an additional 2 000 $km^2$ will be overflown.

Prefectural ordinances thus set the monitoring terms required of the operator.

Administrative policies, from the site's operation to its reclamation and monitoring, are performed by:

- Mine policies pursuant to the Mining Code
- Policies for classified facilities pursuant to the environment code

The competent authorities oversee radiation monitoring carried out by the operator.

In both cases (Mining Code and environment code), controls at these sites are performed by inspectors from the Regional Directorates for the Environment and Spatial Planning and Housing (DREAL) of the Minister of Ecology, Energy Sustainable Development and the Sea (MEEDDM).

The Nuclear Safety Authority (ASN) participates in the monitoring of former mining sites, under radiation protection and in conjunction with the DREALs.

Monitoring inspections of former uranium mines and tailings storage sites also includes:

- The drafting of environmental reviews by the operator, and the use of results
- An examination of environmental reviews by the DREALs (with the support of the ASN for radiation protection)
- A second level check of these environmental reviews by the IRSN

The drafting of environmental reviews by the operator and their checking by the administration essentially pursues three objectives:

1st objective: to acquire better knowledge of the sites

- Some sites not operated by AREVA
- Geographical and cadastral positions
- Identification of mining works and materials
- Public safety: water bodies and ground movements

2nd objective: to acquire better knowledge of impacts

- Environmental impact studies
- Hydrogeological studies to improve the management of water passing through the old mine workings
- Quality of sediments downstream from the sites
- Health: local population

3rd objective: thanks to this improved knowledge

- To reduce emissions at source in terms of quantity and quality
- To reduce diffuse emissions
- To improve the treatment of releases by focusing on 'soft' techniques
- If necessary, to reclaim former sites by integrating them into the local environment
- To re-evaluate environmental monitoring to adapt it to local needs

Regarding the management of uranium mine tailings, a priority of DREAL is to better understand the uses made of them in order to reduce their impacts. With this in mind, any new uses of tailings have been banned. For significant deposits, easements have been established. Another priority is to identify areas in which tailings are dispersed, so as to identify the uses made of land in these dispersal areas. Furthermore, the compatibility of uses must be checked in order to resolve any unacceptable situations.

In addition to surveillance conducted by AREVA NC and checks by the DREALs (including during random inspections with samples collected for analyses), for some sites measurement results are provided by several different agencies. This is the case of sites whose operation has been questioned by the public, elected officials or local or national associations.

Moreover, throughout France, the Institute of Radiation Protection and Nuclear Safety (IRSN) provides permanent monitoring of radioactivity levels in the different ambient media (air, water, soil, food, etc.) with which the public may be in contact. This monitoring is also carried around various former mining sectors which are among the most significant in terms of tonnage and uranium tailings.

#### 4.6.3.1 Measures undertaken by the administration (authorities)

Former uranium mines have been under continuous surveillance by the administration since their closure.

The old uranium mines continue to be managed in a resolute manner with the deployment of several actions:

- Implementation of an action plan described in the circular of 22 July 2009 – (short and medium term)
- Implementation of the National Plan for the Management of Radioactive Waste and Materials (PNGMDR) – (long term)
- Implementation of the Pluralistic Expertise Group for the Limousin region

##### *4.6.3.1.1 Implementation of an action plan (short and medium term)*

The environmental monitoring of mining sites is the operator’s responsibility.

The circular of 22 July 2009 jointly defined by MEEDDM and the ASN (Annex 3) describes the implementation of an action plan and is based on four main points:

1. <u>Controls at former mining sites</u>, including random sampling campaigns and measurements of water and sediments, the operator’s measurement points and specific measurement points. Within this framework of control by the authorities, random sampling campaigns and measurements may be agreed by the inspection team and will be conducted by the IRSN or any other body authorised by the ASN. They must be covered financially by the operator. Where applicable, these inspections may lead to identifying ‘sensitive’ areas to which access should be protected. In this case, the operator will be asked to expedite the work required and these protective measures will be imposed by a prefectural ordinance. Random sampling campaigns and measurements of both water and sediments will be conducted for these inspections. These checks can be performed on points regularly monitored by the operator, as

well as on "specific" points identified by the inspection. Water flows, including at the foot of rock piles or ore processing tailings, should be given special attention. These inspections can also be carried out away from the confines of the mines. The IRSN has also taken measurements at several sites, either occasionally in response to requests from the authorities, or as part of regular monitoring it performs at certain points in the vicinity of mining sites.

2. Improvement of knowledge of environmental and health impacts at former uranium mines, and monitoring operations, in particular through:
    - The requirement of ‘environmental reviews’ at AREVA NC sites with an environmental inventory conducted within 3 years
    - The preparation by the Radiation Protection and Nuclear Safety Mission (MSNR) of the Ministry of Ecology, Energy, Sustainable Development and the Sea (MEEDDM) of a specimen prefectural ordinance in consultation with the ASN
    - Taking into account the GEP recommendations
3. Management of mine tailings: improve knowledge about their uses and reduce impacts if necessary
    - Through an inventory to be drawn up by AREVA NC of the areas in which tailings produced are reused
    - Through a survey of land uses
    - Through a verification of the compatibility of uses at the base and in the environment (in the event of incompatibility: action on a case-by-case basis)
    - where applicable by establishing SUP easement
4. Intensification of information and consultation
    - Role of the Pluralistic Expertise Group (GEP). The GEP final report will be provided at the end of September 2010.

Regarding point 3 (management of tailings), the team took note that in their circular of 22 July 2009 to the department prefects, the Minister of State, the Minister of Ecology, Energy, Sustainable Development and the Sea, responsible for green technologies and climate negotiations, and the President of the Nuclear Safety Authority generally specified not to question past uses of such tailings, but that it is now necessary to:

- Prohibit any new project for the reuse of tailings from old uranium mines.
- Establish easements on lands with significant deposits of tailings from former uranium mines to classify them and prevent their reuse anywhere but on the land where they were deposited.
- Survey areas where such tailings have been used outside the perimeter of old mines.
- Identify land uses where tailings were used outside the perimeter of the old mines.
- Verify the compatibility of uses at the base and in the immediate environment of areas where such tailings have been used.

The circular also stipulated that the identification of areas where tailings are reused must be conducted under the operator's responsibility (subject to the agreement with prior owners of the parcels affected by the presence of tailings), in accordance with the commitment by the President of AREVA NC in the letter sent 12 June 2009 to the Minister of State (Annex 5).

This survey must be conducted as part of a concerted approach involving local information and monitoring committees (CLIS), as well as the public and local elected officials.

It was also stipulated that the census conducted by AREVA NC over a two-year period will be presented to the CLIS and consequently made available to the public in the municipalities affected by the reuse of mine tailings. During this period, the public will be provided with an opportunity to comment on the survey. Following this consultation period, AREVA NC must take this information into consideration in completing the survey.

The team noted that counter-valuations on some sites of primary importance had been entrusted to the IRSN within the MIMAUSA programme. The scope of these counter-valuations is to help judge the quality of the survey conducted by the operator and render this database reliable. Where appropriate, they may also lead to the operator being asked to collect further data.

The team noted that, once this survey has been completed, the uses made of land where tailings have been reused (and the immediate environment of these areas) will be verified to ascertain whether they are acceptable in relation to the environmental and health plan. If their use is incompatible, AREVA NC will participate on a case-by-case basis, as agreed with the Minister of State, in the necessary reclamation actions. Insofar as certain provisions of the Public Health Code must be applied, these situations must be managed in conjunction with the Departmental Directorate of Health Affairs and Nuclear Safety Authority.

In the event that tailings must be removed from areas where they have been used, they should preferably be returned to the site from which they originated, or to any other site authorised to receive this type of waste, taking the principle of proximity into consideration.

This survey is intended to be made available to the public, so that, under the direction of the prefects, variations can quickly be implemented in the local development plans of municipalities where tailings from former uranium mines have been used, in order to prevent the further development of incompatible projects on lands where these materials have been reused.

##### *4.6.3.1.2 Implementation of the National Plan for the Management of Radioactive Waste and Materials (long term)*

The National Plan for the Management of Radioactive Waste and Materials (PNGMDR) is jointly steered by the Directorate General for Energy and Climate under MEEDDM and by the ASN. Since 2003, the PNGMDR has been overseeing the management of former mining sites. The legislation of 28 June 2006 stipulated that a review of the long-term impacts of uranium processing residue storage sites be submitted by late 2008, including the implementation, where necessary, of an intensified radiological monitoring plan of these sites. The first PNGMDR covers the years 2006 to 2008, and the Decree of 16 April 2008 specifies its expectations.

In January 2009, AREVA NC submitted three studies analysing the status of embankments designed to retain stored residues, calculating the dosimetric impacts of these sites over the short and long term (in accordance with the methodology validated by the ASN), and characterising the residues.

The ASN submitted its findings to the Government on 25 August 2009 following the expertise delivered by the IRSN.

The second PNGMDR applies to the years 2009 to 2012.

The review conducted by AREVA NC in January 2009 is a critical step in the process of verifying the safety of residue storage sites. It currently allows for an assessment of available knowledge on the characterisation of residues and the maintenance of embankments surrounding some storage sites.

However, further information is required on certain points pertaining to:

1. Mining residue storage sites
2. Mining sites
3. Mine tailings

**1. Mining residue storage sites**

- Physical and chemical characterisation of residues over the long term: studies continuing (results expected late 2012)
- Evaluation of the status of embankments surrounding the storage sites: supplementary to the geo-mechanical assessment process and requirements for verifying the long-term safety of storage sites (results expected late 2011)
- Reinforcement of the quality of covers: evaluation of the feasibility and relevance over all storage sites containing mine residues (results expected late 2011)

**2. Mining sites**

- Need to reduce waste emissions and improve waste treatment processes: assessment of current water treatment practices, taking into account all chemical and radiological risks (results expected late 2011)

**3. Mine tailings**

- Survey of areas where tailings have been reused (see circular of 22 July 2009 and AREVA NC letter of 12 July 2009): surveying, identification and management of incompatibility situations (results expected late 2011)
- Dosimetric evaluation of reused tailings and stockpiled tailings: finalisation of the adaptation of the methodology for assessing the long-term dosimetric impact of residue storage sites in the event of the reuse of mine tailings (results expected late 2011)
- Physical and chemical characterisation of stockpiled tailings over the long term: correlation with the results of geochemical models developed for storage sites (results expected late 2012)

# 5. FORMER URANIUM MINES IN THE LIMOUSIN REGION AND URANIUM PRODUCTION SITES – DESCRIPTION AND VERIFICATION

## 5.1 INTRODUCTION

The progressive closure of mines has led to reclamation works of varying scale depending on the sites and extent of mining hazards, as well as the potential impact of each site. The most important sites, including residue storage sites and the primary mine sites, were subjected to specific post-closure actions. In some cases, these actions were accompanied by the maintenance of operational capability.

These include:

- continuing to collect and process water leaking from old mine workings which present concentrations of radioactive elements that are too high to be released in nature.

At other sites, they entail:

- simple regulatory monitoring already implemented.
- numerous sites, deemed insignificant at the time of their closure, were closed without specific actions or special monitoring being put in place.

The carrying out of operating reviews by AREVA NC, and operations implemented within the MIMAUSA database of the Institute for Radiological Protection and Nuclear Safety (Memory and Impact of Uranium Mines), are designed to verify the nature of issues associated with all mining sites, including those for which no monitoring was deemed necessary. At other sites, monitoring was carried out and then stopped after a few years of operation based on the results obtained.

## 5.2 THE MONITORING OF MINING SITES IN THE LIMOUSIN REGION

### 5.2.1 Introduction

The reclamation of a certain number of former uranium mine sites was accompanied by the implementation of a monitoring system managed by AREVA NC. This type of regulatory monitoring of the environment, established by prefectural ordinances, can be accompanied by voluntary monitoring actions conducted by the operator, additional monitoring exercised by the Institute for Radiological Protection and Nuclear Safety (IRSN) under its monitoring operations conducted throughout the country, spot verifications conducted by the authorities (Regional Directorates for the Environment and Spatial Planning and Housing (DREAL), the Nuclear Safety Authority (ASN), or even local measurement campaigns (conducted by local associations, communities).

### 5.2.2 Monitoring conducted by the operator

The verification team was informed that the monitoring of a mining site and its environment is first and foremost the operator's responsibility, as for other industrial installations in France. Monitoring is thus conducted within the framework of a self-checking process whose minimum requirements are established by the regulatory authorities (in this instance the prefectural ordinances supported by the DREAL). This self-checking process includes the facilities and their impact, and must be conducted throughout the duration of operations, and subsequently during and, where applicable, after the site's reclamation. Where it currently exists, monitoring aims to check all pathways at and around the site infiltrated by uranium and its by-products - as well as various chemicals related to uranium ore or related mineral and water processing activities.

The team was informed in detail of mining site monitoring operations that focus on checking:

- water pathways: water at the site, waste water, receiving surface water (rivers) and groundwater (farm wells, piezometers);
- the atmosphere: external exposure to gamma radiation, concentrations of radon and its decay (measurements of potential alpha energy - PAE), or atmospheric dust;
- the food chain: concentrations of radionuclides in consumer products (milk, vegetables, meats, fish, water consumption).

### 5.2.3 Administrative controls

In addition to regulatory monitoring conducted by AREVA NC, checks can be effected by the administration (DREAL), especially during:

- measurement campaigns or random sampling collecting by an accredited laboratory of its choice. The costs of such campaigns are the operator's responsibility.
- programmed inspection visits aimed at checking the conformity of monitoring operations conducted by AREVA NC regarding the provisions of prefectural ordinances or national regulations (mine policies, ICPE regulations for sites storing processing residues)

When the monitoring of dose rates, exposure to radon and dust radioactivity has been set up, the data is collected from fixed stations located on the land sites and in inhabited areas considered most at risk. These measurement stations are designed to provide data representative of average exposures received by the public outside their homes.

In practice, the nature and extent of the environmental monitoring devices vary from one site to another: some sites are monitored extensively, while others are not monitored at all, since they are deemed to no longer present any environmental risks. These differences are explained by the peculiar nature of these sites, the importance of source tagging and underlying risks, the nature of released emissions (e.g. the existence of a water treatment plant), and the specific situation of each site (water levels, special use). The monitoring devices thus comply with a principle of proportionality, i.e. adapting monitoring means to the issues at hand.

The team has noted that at sites storing residues, monitoring is systematic and involves all pathways: water, air (ambient dose rates, concentration of radon in the air and dust), as well as products in the food chain.

### 5.2.4 Information on the results of radiological monitoring

The results of these monitoring operations are transmitted to the administration at a rate stipulated by a prefectural ordinance (monthly, quarterly or annually). Periodic reviews can be requested after a monitoring period, generally set at three or five years. Depending on the results, controls can be intensified, alleviated or removed.

All results acquired by AREVA NC as part of their self-checking programme are centralised and rendered accessible on the website of the National Network for the Measurement of Radioactivity in the Environment, managed by the IRSN.

These results can be commented on within the Local Information and Monitoring Committees (CLIS, implemented by prefects and comprising representatives of the authorities, elected officials, associations and the operator) that meet at least once a year.

## 5.3 FOCUS ON OPERATIONS IN HAUTE VIENNE

Based on an analysis of the documents submitted, the verification team noted that the Limousin region, and the department of Haute Vienne in particular, occupies a central place in the history of uranium mining in France. It is the region where the first mine (Henriette) was opened and the last mine (Jouac) was closed. On its own, it has contributed to 46% of French production. The former Crouzille Mining Division (now AREVA NC – Bessines facility) appears prominently in the reclamation effort, both in terms of public authority initiatives and the decision taken by AREVA NC to set up in Bessines-sur-Gartempe its headquarters for the reclamation and monitoring of former mining sites (Post mining Authority - DAM).

From 1948 to 2001, the department of Haute Vienne operated 29 granitic uranium deposits which produced 31 081 tonnes of uranium from 14 356 888 tonnes of ore graded at an average of 2.16 kg of uranium per tonne. The ore was extracted by open-cast mining (OCM) for deposits close to the surface, and from underground mine workings (UMW) for deposits located below the surface. Uranium ore tailings were stored at five sites (Brugeaud and Lavaugrasse at the Bessines industrial site, Bellezane, Montmassacrot and Jouac/Bernardan).

The verification team was informed that these activities were developed north of Haute-Vienne:

- primarily north of LIMOGES, along the road from the A20 motorway, on a strip that is 35 km long (north to south) and 15 km wide (from west to east), touching on the territories of the municipalities of ST SORNIN LEULAC, BESSINES S/GARTEMPE, BERSAC S/RIVALIER, RAZES, ST LEGER LA MONTAGNE, COMPREIGNAC, ST SYLVESTRE and BONNAC LA COTE. This sector is part of the former Mining Division of La Crouzille, operated by CEA and then COGEMA;
- in the extreme northern part of the department, on the edge of the department of Indre and covering the municipalities of JOUAC, CROMAC and MAILHAC SUR BENAIZE. This sector covers the concession on Mailhac sur Benaize, operated by TOTAL Compagnie Minière France (now Société des Mines de Jouac following the company's acquisition by COGEMA in 1993).

Mining activities in the department of Haute Vienne thus involved:

- the operation of 29 mining sites (Mining policy)
- the operation of 2 ore processing plants (ICPE regulation)
- the storage of processing residues at 5 sites (ICPE regulation)

They currently cover:

- the end of reclamation works
- the monitoring of all reclaimed mining and industrial sites
- the management of 6 water treatment plants

Annex 6 provides a figure and table listing the various uranium mining sites in the department of Haute Vienne.

### 5.3.1 The three levels of radiological monitoring at former uranium mining sites

The verification team was informed that the regulatory monitoring and additional monitoring provided at AREVA NC's initiative is exercised at three levels in the department of Haute Vienne (concentric areas of influence from the mine to the environment and the population):

A) An intra-site check verifying the effectiveness of the reclamation process, including the storage of waste, sustainability of the water collection system (runoffs, percolation, mining outfalls) and quality of waste water. This check covers:

- radiological monitoring at monthly or quarterly intervals (soluble and insoluble 238U and 226Ra, sulphates, pH) of the various water pathways identified, allowing for separation at the entrance to the treatment plant where possible (water for treatment and direct waste water);
- the site's hydraulic operation through weekly measurements of mine water flows and piezometric measurements correlated with quarterly rainfall;
- the effectiveness of reclamation work, including the covering of storage sites containing processing residues, via integrated measurements of dose rates (quarterly) and the potential alpha energy of short lived decay products of Rn-220 and Rn-222 (monthly) by placing site dosimeters;
- the stability of embankments and levees for processing residues, through quarterly piezometric measurements and annual topographical measurements (altimetry, planimetry).

B) A check of mainly water discharges and their impact on water quality. This check covers:

- weekly concentrations of radionuclides released from the site (treated or directly discharged), paying special attention to compliance with regulatory values (variable depending on the site and determined by the administration according to the sensitivity of the receiving environment), allowing for an evaluation of the treatment effectiveness (% reduction of uranium and radium radionuclide concentrations in water after treatment). The use of treatment products (aluminium and barium) and the chemical signature of the mine water (iron, manganese) for monthly chemical analyses of these elements. The annual evolution of waste water is expressed in terms of concentrations (Bq/l or mg/l), as well as in terms of flux emitted (kg of uranium and MBq of radium discharged);
- concentrations measured (U-238 and Ra-226, soluble and insoluble) in receiving environments, through monthly samples taken over water to incorporate the effects of dilution. The impact is assessed by comparison with measurements taken on samples of so-called "reference" upstream discharges;
- potential impacts (U-238, Ra-226, sulphates, heavy metals) on underground water, including at arenite levels captured by farm wells in the residue storage environment (sampling frequency from monthly to half-yearly according to requirements);
- impacts on the aquatic environment with annual sediment samples (U-238, Ra-226, Th-230, Pb-210) and more locally with samples of aquatic plants.

C) The acquisition of specific data to assess the dosimetric impact on population groups living in the vicinity of the sites, the so-called reference groups, potentially subject to their influence. This check covers:

- the air quality, estimated from measurements acquired by dosimeters at the sites (measurement of potential alpha energy of Rn-220 and Rn-222 expressed in nJ/m3, activity measurements of airborne dust in air Bq/m3) and thermo-luminescent dosimeters (measurements of dose rates expressed in nGy/h) placed at the centre of towns and villages in the reference groups taken into consideration;
- the food chain, from measurements acquired by samples of vegetables, meat, milk, fruit and drinking water (U-238, Th-230, Ra-226, Pb-210, Po-210) in the towns, and fish from major waterways.

All of this monitoring data is collected for the purpose of providing an impact assessment. This is based on an assessment of the effective dose and its comparison with so-called "natural reference environment" stations (4 stations) to ensure compliance with regulatory standards, according to which the dose added for members of the public due to mining and industrial activities must be kept below 1 mSv per year (Article R. 133-8 of the Public Health Code).

### 5.3.2 The Industrial Site of Bessines

The Industrial Site of Bessines (SIB) is situated on the northern flank of the Gartempe valley, a tributary of the Loire through the Creuse and Vienne. The surrounding landscape consists of meadows, fields and woodland.

The site covers an area of 140 hectares, which includes an entity outside the scope of liability of AREVA NC: the company ALGADE.

Other facilities at Bessines:

- administrative offices
- the archives of Business Group Mines (BGM)
- the information technology department
- the Lavaugrasse processing residue storage site
- the disused building of the workshop for the preparation of solid waste (APES)
- the Brugeaud processing residue storage site
- the water treatment plant
- the pumping station for mine water from the old mill
- the storage of depleted uranium oxide
- the Process and Analyses Studies Service.

The verification team was received at the Bessines site, where the opening meeting for the verification was also being held in administrative buildings of AREVA NC.

#### 5.3.2.1 Visit and verification of the Industrial Site of Bessines (radiological monitoring and reclamation/redevelopment actions conducted by AREVA NC)

The verification team was informed that that AREVA NC has implemented an integrated Environment/Safety management system, which combines, among other things, sampling, monitoring and measuring operations to ensure that the primary characteristics of all operations and activities are performed correctly. The procedures include recording information enabling performance monitoring, appropriate operational checks, conformity to regulatory requirements; it describes calibration and maintenance rules for equipment enabling its implementation, and the various operations required to obtain the most reliable and most accurate values possible.

The verification team visited the industrial site of Bessines situated on a plateau at the bottom of which runs the Gartempe river. The team conducted a number of checks on this site. Fig. 4 shows a schematic description of the site.

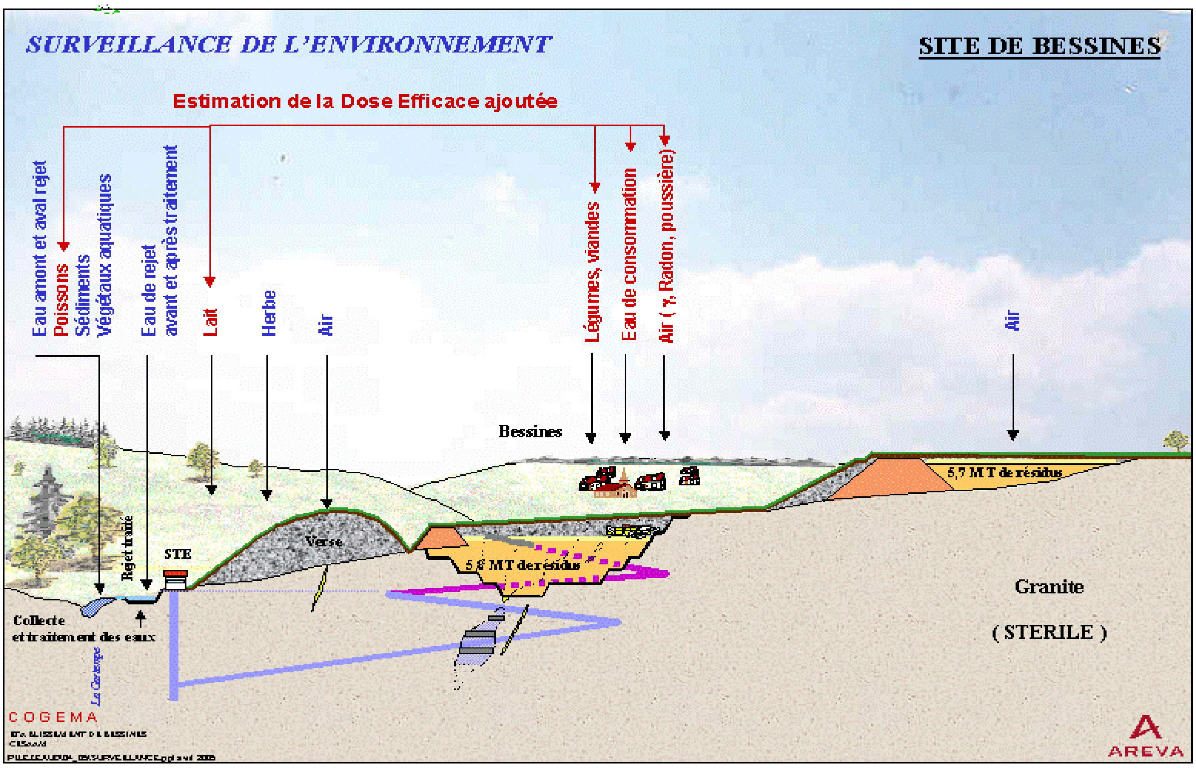


Fig. 4 : Schematic description of the Bessines site (©AREVA)

Using comparative photographs, AREVA personnel showed the team what the industrial site of Bessines looked like in 1978 (during full operations) and in 2010 following the complete stoppage of operations and after the completion of the site's reclamation (or nearly).

The team visited the residue storage sites at Lavaugrasse (closed off to the valley by a dam) and Brugeaud (a former open-cast mine, used for storing residues). These two sites were completely reclaimed, with a 2 m coverage of mine tailings and 0.5 m of soil. AREVA NC keeps the grass mowed on its surfaces and ensures that no trees or shrubs grow on this coverage, possibly damaging it with their roots.

At the Lavaugrasse site, a "buttonhole" remains to be closed (used until recently to collect the sludge from the site's water treatment plant). AREVA NC informed the team that the coverage for this site will be partially rebuilt and completed to provide a 2 m coverage of mine tailings and 0.5 m of soil everywhere (thus ensuring effective protection against radiation as prescribed by law).

The team was also informed of the regular monitoring of embankments at these residue storage sites (stability, sealing, etc.). The embankments also feature planted shrubs (protected from game animals by electric fencing) enhancing their stability. AREVA NC has developed models for different scenarios for the dams and embankments (e.g. the bursting of a dam, etc.).

The team visited the water treatment plant situated below the residue storage sites in the Gartempe valley. The team was informed that this plant operates on the same physical/chemical principle as the one at the Augères site (chapter 7.3.2). All runoff, filtration, drainage water, etc. from the Bessines site is identified, collected and pumped to the plant to be treated. This water then passes through two settling ponds before being discharged into the Gartempe river.

The water in the Gartempe is monitored regularly both upstream and downstream (6 km) from the Bessines site.

AREVA NC monitors the air quality using several dosimeters at the site and at each of the neighbouring towns and villages (monthly measurements; TLD; DLT quarterly measurement). At the site, the team verified the operation of an air sampler (*ALGADE type D*, *CRPM*, no. D 532). AREVA NC regularly checks its operation, submitting the 'head' (comprising the filter, etc.) to the ALGADE laboratory (situated on the site) for measurements (global alpha and radon, on a monthly basis). Natural radioactivity is measured at reference points and subtracted from the measured values.

The team was informed that the concentration of radon largely depends on the topography of the sites. Thus, the highest concentrations are detected in poorly aerated narrow valleys, and not on the surface of reclaimed residue storage sites. The "natural" portion of Radon is often very high in the Limousin area.

The team also witnessed a demonstration of the "sediment traps" used to collect sediments from Lake Pardoux (chapter 7.3.7). A sediment trap consists of a square funnel (50x50 cm opening) that is suspended at a depth of about one metre in the lake water, and gathers "bottom" sediment (suspended solids in the water). The other trap consists of an aluminium block with a glass test tube inside (open on both sides). This block is pushed into the lake sediments (it is dropped). A mechanism closes the bottom of the glass tube with a valve, thus preventing the sediments from escaping the test tube.

The team was also informed that the industrial site is used – among other things - by AREVA NC for the storage of depleted uranium from the production of EUROFDIF/Georges Besse. Approximately 120 000 tonnes are stored here (EURATOM control).

The team was shown a presentation of the RNM database (National Network for the Measurement of Radioactivity in the Environment), and selected measured values from this database in order to conduct a "tracing".

##### *5.3.2.1.1 Water Department*

The team visited the water department at AREVA NC. The department coordinator had a list of work to be performed based on the prefectural ordinance. This list was completed with a sampling sheet for each sampling point (including a map, access details, photos, history, etc.).

The office also had a table for each sampler, with indications of sampling dates, for which the sampler must enter notes/feedback regarding sampling operations, etc. Upon completion of a task, it was text marked in colour in the table. Thus, the department coordinator can check at any time what remains to be done for the month.

Occasionally, the sampling coordinator carries out a check/guided tour (especially with new staff). This is documented in a form signed by the coordinator and staff member.

This service also maintains a Quality Assurance Plan (QAP).

Plastic bottles for water sampling are prepared and marked in advance (code, date, acidification, etc.) in a corner of the laboratory. Once samples have been taken, they are sent off to be analysed at the SEPA laboratory (chapter 7.3.1.2), with an 'EXPR' number and accompanied by a sampling sheet including all sampling details. SEPA returns these sampling sheets to the water department with the measurement results. The results are entered in a book and marked with different colours indicating whether they are "conforming" or "nonconforming".

Regarding the "tracing" of the Augères sample chosen by the team in the RNM database, the binder containing the data was quickly found based on its internal number (*EXPR*): Augères, 3.12.2009 (week 49) Ra-226 soluble 0.10±0.02 Bq/l; 26.11.2009 (week 48) U 20±2.0 µg/l, analysed 28.12.2009; ?10.12.2009 (week 50) total alpha 0.83±0.11 Bq/l, analysed 28.12.2009. The "tracing" confirmed the accuracy of the measured values. The coordinator also had a copy of the report to the DREAL-Limoges including a table showing the measured values.

*The verification did not give rise to comments.*

##### *5.3.2.1.2 Analysis Process Study Service – AREVA NC Analysis Laboratory*

The AREVA NC Analysis Laboratory of the 'SEPA Analysis Process Study Service' is ISO 17025 accredited (COFRAC, 1996). A staff of about thirty work in the laboratory, which participates in intercomparisons organised by the IRSN on a regular basis.

The laboratory operates a 'SMILE' LIMS - laboratory information management system.

<u>Recording and preparation of samples</u>

Two people are responsible for receiving the samples, conducting controls and entering the sample data in the EXPR file-based LIMS; they also print labels (barcodes) which are affixed to the bottles and analysis slips before being sent off to the laboratory for analysis.

<u>Radium analysis</u>

The team visited the measurement laboratory for radium-226 in liquid samples, and received a demonstration on this measurement technique. Firstly, a one litre sample is reduced to a volume of 50 ml by evaporation. The sample is then transferred to a bubbler for degassing. After a period of five days (allowing for the decay of Rn-222), the liquid is poured into a 'Lucas' cell (a sort of ball with a glittering phial, produced by ALGADE) to be measured.

Six of these devices in the laboratory make use of a new type of photomultiplier (*ARIES*, Chatillon CEDEX, FR, PC based). The flasks are marked with indelible codes corresponding to those on the sheets accompanying the samples. The method has a detection limit of 20 mBq/l. To ensure the quality of this method, the laboratory participates in intercomparisons organised by the IRSN.

Uranium analysis

The uranium analyses are conducted using "ICP" (*Inductively Coupled Plasma*) devices. The verification team observed two classic type ICP-OES (*Optical Emission Spectrometry*) devices, a *HORIBA Jobin Ivon Ultima 2* and a *Varian 720-ES*, as well as an ICP-MS (*Mass Spectrometry*) *Thermo Elemental X-Series* device. The team was informed that the method allows for the detection of 1 µg/l U 'without any problems'.

In total, the laboratory has 4 OES type and 2 MS type devices, all equipped with automated samplers. All this equipment is covered by a maintenance contract (72 hr response time).

The standards used for calibration for the most part are from *SPEX* (USA), *UNBL* (USA), IAEA, *CanMet* (CDN) and *Science* (DE).

Gamma Spectrometry

Gamma spectrometry is used for measurements on solid prospecting samples, etc. (measurement of radionuclides for radioactive families Th, U-235 and U-238).

The team visited the gamma spectrometry room kept at atmospheric pressure (avoiding Rn related problems). This room is only accessible through an airlock. The team noted the presence of a 37% HPGe detector (*EURISYS/Canberra n-type*, with a heat exchanger for 36 samples; 10 cm Pb; *Ortec InterWinner 7.0* analysis software) and a 50% HPGe detector (type Rege, *Canberra*; *Canberra Gamma Analyst*; with a sample exchanger; *Canberra Genie 2000*, *Canberra APEX* software).

The geometry used normally is cylindrical for 30°g samples.

A calibration is performed every four years and/or after each major change in equipment.

Effectiveness monitoring is conducted regularly with a certified sample. An energy check is performed when deemed necessary; background noise is analysed on a monthly basis; resolution is also checked once a month.

Standards used are from *CanMEt* and IAEA (environmental reference materials).

Liquid nitrogen is supplied by Air Liquide once a week on a contract basis. A tank is installed outside the building for this purpose.

Quality Assurance

The laboratory is ISO 17025 accredited (COFRAC, 1996). The accreditation covers alpha, beta and gamma measuring techniques. The laboratory also holds ASN approval for environmental radioactivity measurements. The laboratory regularly participates in intercomparisons organised by the IRSN.

Measurement results for total alpha and radionuclides are transmitted to LIMS manually for the moment; transmission interfaces are used for ICPs. The transmission is electronic from the LIMS. The team was informed that interfaces were being installed for all measurement methods.

Reporting

Measurement data are regularly transmitted to the regional and national authorities.

> *To avoid all possible manual transmission errors, the team encourages the installation of automatic transfer interfaces for sending measurement results to the LIMS system.*

##### *5.3.2.1.3 ALGADE: Dosimetry Laboratory in Bessines*

**Introduction**

ALGADE was created in 1993. It was previously a CEA/IPSN service providing radiation protection services for the mining industry, specialising in exposure measurements for miners through measurements of atmospheric radon and its progeny, and the environmental monitoring of Ra-226 and uranium in water systems. ALGADE is a founding member of the National Union of Radon Professionals. Since 2001, ALGADE is part of the *CARSO* group of companies, which provides analytical services in the areas of water systems and the environment, food safety, industrial and building health and hygiene, genetic identification, health and cosmetology.

ALGADE is a laboratory approved by the Ministerial Decree of 25 July 2006 for measuring the activity concentration of radon in public places. The laboratory has the following accreditations and approvals:

- Approvals of laboratories for the control of radioactivity in the environment, Decision No. 2007-DC-0023 of the Nuclear Safety Authority;
- Approval of the Ministry of Health and Solidarity – Measurement of Radon activity concentration in public places, issued by the decree of 25 July 2006, Approvals from the Ministries of Health and Labour for the control of radiation protection in industrial and medical fields;
- COFRAC-135 accreditation – “Radionuclides in the environment: Laboratory analyses of radionuclides present in all types of environmental samples”;
- ISO9001 certification – Version 2000 for the design and manufacture of measuring instruments.

ALGADE instruments and procedures are also used in uranium mines in Canada, Namibia and Gabon. During the inspection of the ALGADE laboratory in Lyon on 30 May 2008, the verification team was informed that the ALGADE production installations are accredited by COFRAC for the measurement of Radon and its progeny. A Radon dosimetry instrument was developed in the 1980s. This instrument features a TLD and is currently used by four laboratories (in Canada, Germany (*Wismut*), the Czech Republic and France (ALGADE)).

To ensure the quality of measurements taken, the laboratories sub-contracted by ALGADE must be approved by the ASN and if necessary accredited by COFRAC. Intercomparisons play an important role in the approval of laboratories. These exercises ensure quality and measurement accuracy.

From a radiation protection standpoint, ALGADE provides expertise for industry (radiation protection for workers), the medical and dental sectors (analysis and checking of hospital waste), building and construction sector (management issues related to radon), and the environment.

ALGADE specialised laboratories:

- The Laboratoire d'Exploitation Dosimétrique (LED) [Dosimetric Mining Laboratory] situated in Bessines-sur-Gartempe, where atmospheric substances are analysed. The following analyses are carried out:
    - Rn-222 and Rn-220 detection and their progeny;
    - Alpha emitters in sampled aerosols;
    - Thermo-luminescent dosimetry;
    - Gamma and alpha spectrometry.
- The Environmental Analysis Laboratory situated in Lyon, where analyses are carried out on natural and artificial radionuclides in industrial water, drinking water, soil, sediment, flora, fauna, the food chain, hospital materials and waste products.

The Environmental Analysis Laboratory in Lyon was inspected during the verification at the Tricastin site (France) in 2008.

For specific tasks that cannot be undertaken by ALGADE, other ASN approved and COFRAC accredited laboratories are called on (e.g. *Subatec* in Nantes or IRSN).

**<u>ALGADE Dosimetric Mining Laboratory in Bessines</u>**

The verification team was informed that the ALGADE Dosimetric Mining Laboratory (LED) situated in the industrial district of Bessines operates in the atmospheric and health impact domain. LED also provides analyses related to the food chain and other fields.

<u>Rn-222 and Rn-220 detection and their progeny</u>

The explanation provided to the verification team was that this is a measuring instrument developed in the 1980s for Radon dosimetry at uranium production sites. Three of these alpha dosimetry instruments are installed at the Bessines site. They are operational 24/7. The filters are changed on a monthly basis.

The team also viewed a version equipped with solar panels; this version is mostly used for measurements in the towns and villages around mining sites. The site also features a reference station.

The head of the dosimeter contains a sheet of cellulose nitrate (*CR115*) with a screen of a different thickness for 'filtering' Po-218, Po-214, Po-212, Rn; a sort of 'alpha mechanical spectrometry'. At the laboratory, the potential alpha energy (nJ) is calculated after the analysis, and based on this finding the concentration (nJ/m$^3$), exposure (mJ/m$^3$ h), and effective dose (mSv).

The dosimeter is equipped with a *Millipore* filter for an overall classic alpha count (long-life alpha emitters). The ambient dose rate - H*(10) – is recorded by TLD (LiF) at the same location (3 month exposure time). The team was informed that the results of measurements are always expressed in relation to the values measured at a reference location.

The team visited the dosimetry laboratory and witnessed the preparation of the equipment 'heads' for the analyses. The laboratory's capacity is 2000 heads (including those from mines in Nigeria). The heads are recorded through barcode identification and data collection sheets. After removing the heads, sheets of cellulose nitrate are placed on supports (disk). This system is also used in the Czech Republic, Canada and other countries. The sheets (films) are developed in a soda bath that lasts an hour; roughly 300 sheets can be placed in a bath.

Tracks are counted automatically. The very first automatic disk reader with optical film for counting alpha particle tracks was designed and manufactured by ALGADE. Another readout system with a *Nikon* camera connected to a PC is used for control, verification and calibration. This system also provides automatic readings. The laboratory has four readers in total.

A "radon chamber" is used for radiation references. It is tested by intercomparisons with an institute in the United Kingdom (*NRPB*).

The equipment for measuring long-life alpha particles in aerosols is kept in a ventilated cabin. Several Si detectors are installed in a vacuum. An automated sample changer (*GT UMI RTX robotic*) is used to place the filters. The team was informed that this system is beginning to age and maintenance is becoming difficult; there were 16 Si detectors originally, of which four have now been disassembled. Calibration with a reference filter is performed regularly (source activity corresponding to the environment, can be U, Pu).

<u>TLD reading</u>

The verification team noted the presence of several TLD readers: two *Alnor Dosacus TLD readers* (with "verified/to be verified labels …" and the date); and a *RADOS RE2000 TLD reader*.

<u>Gamma spectrometry</u>

The team noted the presence of two gamma spectrometry chains.

<u>Alpha and Beta counts</u>

The team noted six alpha spectrometry chains.

<u>Quality Assurance</u>

This laboratory holds thirty accreditations and 15 approvals. It regularly participates in intercomparison exercises organised by the IRSN.

*The verification did not give rise to comments.*

### 5.3.3 The Fanay/Augères site

The mining sites at Fanay/Augères lie within a perimeter that runs 3 km north-south and 2.5 km east-west, starting 2 km south-southeast of Razes. This space enclosed 17 underground workings, all interconnected by tunnels. These sites and their old ventilation works are all being refurbished and returned to their natural state. They can be grouped into 12 geographical areas, in addition to another 8 small scattered lots. These sites have in common that they are all situated in the hilly and heavily forested terrain of the Ambazac mountains.

The team visited the water treatment plant at the Augère site.

Access to the site is closed off by a fence whose entry gate was locked. A sign on the fence explained that the site is off limits, providing reasons for its prohibited access.

The plant processes the overflow water of about 70 km of underground tunnels. The pool collecting mine water is down in the valley at a lower level than the river to avoid possible overflow into the river. From there the water is pumped to the water treatment plant which is located upstream of several settling ponds.

The plant comprises a building housing the actual processing of uraniferous water collected, a storage pond and several settling ponds.

The plant's coordinator explained to the verification team that before treatment the water from the storage pond has a uranium content of 100 to 150 µg/l and around 0.7 Bq/l of radium. To treat the collected water, AREVA NC makes use of a physical-chemical process based on the addition of $BaCl_2$ and $Al2(SO_4)_3$. Barium chloride causes the precipitation of radium, and aluminium sulphate causes the precipitation of uranium. Chemically, it is co-precipitation of uranium with a precipitate of iron hydroxide (AlOOH, $Fe(OH)_3$). The team visited the facilities inside the building, which consisted of two tanks of about 3000 litres for the storage of liquid chemicals, and a channel to mix these products with dosages added to water being treated before it is transferred into the first settling pond. Exiting several settling ponds, the water flows out of the treatment plant and is released into the Ritord river. The team was informed that when it leaves the plant the water has a radium content of around 0.05 Bq/l and a uranium content of 30 to 70 µg/l. Around 20% of the initial contamination in Ra and U thus remains, and is currently still released in nature.

The team was also informed that AREVA NC officials are currently exploring new methods to purify this water to a very high percentage before being released. Aside from the physical-chemical purification at the Peny treatment plant, a prototype using a new process that is much *softer* (using tree bark) is being tested at this site (description: see 5.3.4).

At the exit point from the last settling pond, the team verified a system for the automated sampling of discharged water, manufactured by "*Umweltmesstechnik ORI*", Bollacken 2, D-32479, Hille, Germany. Every 90 minutes, the sampler withdraws 120 ml of water and transfers it into a container of around 20 litres. This container is changed on a weekly basis and measured once a week. An operating manual was found inside this piece of equipment.

AREVA NC also regularly takes water samples from the river.

*The verification did not give rise to comments.*

### 5.3.4 The Margnac/Peny site

The mining sites at Margnac lie within a perimeter that runs 3 km east-west and 3.5 km north-south, starting 3.5 km southwest of Razes and 1 km northeast of Compreignac. This space enclosed 10 underground workings, all interconnected by tunnels. These sites can be grouped into 11 geographical areas, in addition to another 3 small lots scattered throughout the hills.

The team visited the water treatment plant at the Margnac/Peny site.

Access to the site is closed off by a fence whose entry gate was locked. A sign on the fence explained that the site is off limits, providing reasons for its prohibited access.

The site's water is currently purified using the same process described for the Fanay/Augères site. However, an innovative process based on the absorption of ions on a natural matrix and its regeneration after use is still being studied.

The team was informed that, in cooperation with the chemistry laboratory of natural substances (LCSN) of the University of Limoges, AREVA NC is pursuing an R&D project on this site to develop a new water treatment method as an alternative to the physical/chemical treatment. This process uses the power of tree bark to absorb uranium and radium. The team observed the prototype and was informed that the bark functioned as an ion exchange resin and could be regenerated after use (thereby allowing it to be used a number of times).

The team was informed that based on tests with this prototype and laboratory tests, there was evidence that the process purified treated water to more than 99% of its Ra and U content. Assuming it can be exploited at an industrial level, this process presents an excellent alternative to the physical/chemical treatment currently used and, moreover, would be significantly more effective. A demonstration prototype is currently being tested at the site.

One of the advantages of the process, aside from its greater efficiency, is that no toxic substances are released into the environment after use (Ba etc.).

The team was also informed that the university institute is conducting trials on various tree barks to specially condition them in an effort to increase and render more specific their capacity to absorb certain nuclides.

An industrial facility to exploit this new process is scheduled to be built on the site in 2011, assuming that the current prototype tests are conclusive.

> *The verification did not give rise to comments. The team supports cooperation between the University of Limoges and AREVA NC to develop a biological treatment for uranium water that is based on tree bark.*

### 5.3.5 Puy de l'Age

The Puy de l'Age site is situated 4.5 km southeast of the Industrial Site of Bessines, on the northern side of the Bois des Echelles, a mountainous and steep forested region.

The team visited the site, which is a model for the successful redevelopment of a former uranium open-cast mine. The mining site was flooded and now appears as a body of water (maximum depth 25 m) surrounded by meadows and made available to the fishermen's association "Le Martin Pêcheur" for the promotion of fly fishing.

The team was informed that the lake water analysed and measurements taken on fish in the lake have shown that concentrations of radium and uranium are far below the limits prescribed by law (prefectural ordinance). This allowed the prefecture to inform AREVA that environmental radiation monitoring is currently no longer required now and the site can be used by the public as a recreational area.

AREVA NC sold it, preserving a body of water surrounded by meadows and making it available to a fishermen's association, while keeping it fenced for safety reasons (protection against drowning). AREVA NC has continued the voluntary radiological monitoring of the site for documentation purposes.

*The verification did not give rise to comments.*

### 5.3.6 The "Bernardan-Cherbois" site in Jouac

The "Bernardan-Cherbois" site lies halfway between Lussac-les-Églises and Mailhac-sur-Benaise, within the territory of the municipality of Jouac, 54 km north of Limoges. It is surrounded by meadows and woodland. The site enclosed the mining complex of Jouac, which comprised a processing plant (dismantled), offices (sold to local businesses), an opencast mine (which is being filled with water), and underground mine workings that are being rendered secure. The entire site was redesigned and fenced off. The area is returning to its natural state, with the exception of the water treatment plant and its ponds, north of the site.

This site, which belonged to TOTAL (mining division), was bought in 1993 by AREVA NC in a deal in which AREVA NC bought all of TOTAL’s mining activities. This mine was closed in 2001, the last uranium mine in operation in France.

The water is treated on site by a physical/chemical process that differs slightly from the process applied at the Augères and Peny sites. In this process water with a high content of iron salts is firstly mixed with slaked lime ($Ca(OH)_2$) to achieve a pH value of about 9.5 (precipitating the iron as iron hydroxide $Fe(OH)_3$). This causes a co-precipitation of uranium. The silo storing the slaked lime has a capacity of 75 $m^3$. Both complexes (Fe and U) settle rapidly. $BaCl_2$ is also added to eliminate the Ra-226.

The process also uses $Ba(Cl)_2$ and $Al_2(SO_4)_3$ to precipitate the Ra and remaining U. In the event of problems with the slaked lime, it can be replaced by NaOH. The treated water passes through two settling ponds before being released into the river.

The treatment capacity is 100 $m^3$ per hour. Before discharge, an automatic receptor takes samples of the treated water. A generator ensures the plant’s smooth operation in the event of a power outage. At the time of our visit, there was a low water inflow to the mine (~ 5/6 $m^3$ per hour). The opencast mine is currently being flooded, and will overflow at some point. The plant’s large capacity is designed to allow for the treatment of the overflowing water in the future. The mine "crater" is currently being filled with water at a rate of about 15 $m^3$/h. Estimates are that its complete filling will take another 10 years. 16 piezometers have been placed around the site (to a depth of 75 metres).

The entire water treatment process is automated. It is controlled by a technician (and a backup in case of illness) on site, and monitored from Bessines. In the event of abnormalities in pH levels, treatment is stopped automatically and an alarm is triggered in Bessines, where a team is on call, ready to resolve any problems. The team was shown a presentation on a PC by the technician, describing all of the procedures at the workstation.

A small rescue station can replace the normal station in the event of a malfunction.

*The verification did not give rise to comments.*

### 5.3.7 The Bellezane site

The Bellezane site is situated 2.5 km southeast of the Industrial Site of Bessines, on the edge of the Gartempe valley. The landscape consists of meadows and fields with some woods. The site has been redeveloped but some buildings remain, together with a large excavation where ore processing residue is stored, and sludge ponds.

A water treatment plant is maintained on the site, with its ponds.

The remaining buildings were sold to the construction company *MISTRI*, which occupies the former offices of the Bellezane mine, and to *SCI GIROBI (KODECA)* which bought the old opencast mining yard and a workshop building.

Before visiting the old mining site at Bellezane, the verification team met with two technicians who take samples of groundwater from the piezometers for AREVA NC. The team witnessed a demonstration of a groundwater sample being withdrawn at the verge "PZ60". The piezometer was locked; it had a diameter of 64 mm, and a depth of 25 m. The water level was 10 m.

To avoid withdrawing stagnant water, the sampler emptied the piezometer three times with a pump (suspended below the sampling device) for 30 minutes before taking the sample. The pump is set by a *Grundfos BMI/MP1-230V* regulator. There are also deeper piezometers on the site.

The site of the former opencast mine was fenced off and locked. Part of the old opencast mine has already been reclaimed, with a coverage of tailings (2 m) and soil (0.5 m). Dosimeters were set up on this surface, operated by solar panels and protected against vandalism by cages. There are also several piezometers on the site. On one side, the site is used as a storage for sediment (Lake St. Pardoux) and sewage sludge from the mine water treatment plants. This storage area is reaching its limit and will have to be closed shortly and reclaimed with a coverage of tailings and soil, just like the rest of this site.

An underground tunnel drains runoff to the mine's water treatment plant, situated at the other side of the mountain. This treatment plant is fenced off and locked. The mine water pours out through several pipes on the hillside, well separated from uncontaminated waters that flow directly into a small canal leading to a receiving stream (which was dry at the time of the verification). Since there is no dilution of the 20% contamination remaining after the water's physical/chemical treatment, this poses a large problem because discharge values established by the authorities are exceeded. To solve this problem, the site is primed for the installation of a "bark process" which eliminates contamination at a rate of over 99%. Downstream from the settling pond, the samples taken by two piezometers are representative of all the groundwater drained from the site.

*The verification did not give rise to comments. The team supports the installation of the new uranium water purification prototype, which makes use of tree bark to purify the water and provides very promising results (over 99%); to be confirmed in the industrial phase.*

### 5.3.8 Lake St. Pardoux

Lake St. Pardoux is a tourist site with an area of approximately 330 ha.

It is fed by several rivers, including the Ritord river. The latter receives treated wastewater from the Fanay mine site, which still contains about 20% Ra and U in their original form after purification.

Over time, this has created sediments at the mouth of the Ritord exceeding 5000 $Bq^{/kg}$ (Ra-226 plus U-238). The limit stipulated by prefectural ordinance is 3700 $Bq/^{kg}m^3$. When the lake was last drained, AREVA NC removed these contaminated sediments to store them in the former opencast mine at Bellezane. With the new mine water treatment process using tree bark planned at the Fanay/Augères site, AREVA NC hopes to achieve the level requested by the prefectural ordinance.

*The verification did not give rise to comments.*

## 6. CONCLUSIONS

All programmed verifications were carried out without difficulties. In this respect, the file provided beforehand together with the onsite handouts proved very useful.

The main conclusions of the verification are:

(1) The verification work performed indicates that the necessary facilities for the permanent monitoring of radioactivity levels in the air, water and soil around the former uranium mining sites verified in the Limousin region are adequate. The Commission verified the operation and efficiency of the facilities in place;

(2) The team supports certain initiatives and activities, including the development and testing of a new water treatment process for uraniferous waters. The team observed the conformity of the sites visited with the provisions of Article 35 of the Euratom Treaty;

(3) The verification team proposes sharing France’s expertise in the areas of environmental monitoring and the management of former uranium mining sites with EU Member States facing the same problem issues;

(4) The comments are detailed in the "key findings", addressed to the competent French authorities via the Permanent Representation of France to the EU.

Lastly, the verification team wishes to thank its partners for their cooperation and availability.

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**ANNEX 1**

**PROGRAMME SUMMARY OF THE VISIT**

# Art. 35 FR verification – 14 to 16 September 2010

# Former uranium mines in the Limousin region

**Monday 13 Sept.**

Travel day for the EC team from Luxembourg/Karlsruhe to Limousin (Limoges).

**Tuesday 14 Sept.**

1. Bessines: Opening meeting - Applicable administrative and regulatory framework (MSNR, DREAL, ASN, IRSN), presentation of the mission by EURATOM representatives. (morning, 09:00)
2. Overview of uranium mining in France; monitoring and controls, studies, action plans (AREVA NC). (afternoon)
3. Verification: Visit to Augères (Studies for the optimisation of a water treatment plant); visit to Peny (R&D on alternatives to physical/chemical treatments). (afternoon)

**Wednesday 15 Sept.**

4. Verification: Visit to the Industrial Site of Bessines (monitoring and measuring, water treatment plant). (morning)
5. Verification: Visit to the SEPA laboratories (water) and ALGADE laboratories (air and food chain). (morning)
6. Verification: Visit to Bellezane (monitoring and measuring, studies, water treatment plant); Visit to Puy de l'Age (end of monitoring, reclamation of a site for recreational use). (afternoon)

**Thursday 16 Sept.**

7. Verification: Visit to Jouac (decentralised mining site); Visit to Ritord/Pardoux pond. (morning and afternoon)
8. Feedback meeting. (afternoon, 17:00)

**Friday 17 Sept.**

Travel day for the EURATOM team returning to Luxembourg/Karlsruhe.

European Commission team: Constant Gitzinger, Eberhardt Henrich, Erich Hrnecek

Team leader: Constant Gitzinger

**ANNEX 2**

## DOCUMENTATION

The following documents were used for the preparation of this report:

**Briefing completed under the coordination of the Euratom Scientific and Technical Committee.**

## Internet links

In addition, the following websites can be consulted:

Regulatory aspects

- Mining Code:
  http://www.legifrance.gouv.fr/affichCode.do?cidTexte=LEGITEXT000006071785&dateTexte=20100719

- Environment Code (Title 1 Part V only):
  http://www.legifrance.gouv.fr/affichCode.do?cidTexte=LEGITEXT000006074220&dateTexte=20100719

- Public Health Code (articles from the first section – Part III – Title III - Chapter III only):
  http://www.legifrance.gouv.fr/affichCode.do;jsessionid=81E4563252DF7304D25AE6863AFF93FB.tpdjo10v_1?idSectionTA=LEGISCTA000006171595&cidTexte=LEGITEXT000006072665&dateTexte=20100720

- Nomenclature of classified facilities + Decree no. 2006-1454 of 24 November 2006 (ICPE):
  http://www.ineris.fr/aida/?q=consult_doc/navigation/2.250.190.28.6.2240/5
  http://www.legifrance.gouv.fr/jopdf/common/jo_pdf.jsp?numJO=0&dateJO=20061126&numTexte=23&pageDebut=17787&pageFin=17789

Other sites related to the management of former uranium mines

- The MIMAUSA programme:
  - database:
    http://mimausa.irsn.fr/Mimausa/
  - MIMAUSA inventory:
    http://www.irsn.fr/FR/base_de_connaissances/Environnement/surveillance-environnement/surveillance-mines-uranium/Pages/3-inventaine_national_des_sites_miniers_d_uranium.aspx?dId=55cbcb33-1e47-4d6e-b762-3a61de5657f0&dwId=b95b3478-7e0e-46c1-af3a-397745dcc19b

- The PNGMDR :
  http://www.asn.fr/index.php/S-informer/Dossiers/La-gestion-des-dechets-radioactifs/Le-cadre-reglementaire/Le-Plan-national-de-gestion-des-matieres-et-des-dechets-radioactifs-PNGMDR

- GEP (Pluralistic Expertise Group on uranium mining sites in the Limousin region): http://www.gep-nucleaire.org/gep

- AREVA NC: http://www.areva.com

Institutional sites

- Website of the Ministry of Ecology, Energy, Sustainable Development and the Sea (MEEDDM): http://www.developpement-durable.gouv.fr/

- ASN website: http://www.asn.fr/

- IRSN website: http://www.irsn.fr/FR/Pages/home.aspx

**ANNEX 3**

## CIRCULAR OF 22 JULY 2009 ISSUED BY THE MINISTRY OF ECOLOGY, ENERGY, SUSTAINABLE DEVELOPMENT AND THE SEA (MEEDDM) AND THE NUCLEAR SAFETY AUTHORITY (ASN)

Ministry of Ecology, Energy, Sustainable Development and the Sea, responsible for green technologies and climate negotiations

Nuclear Safety Authority

Paris, **22 July 2009**

**The Minister of State, Minister of Ecology, Energy, Sustainable Development and the Sea, responsible for green technologies and climate negotiations**

**and**

**The President of the Nuclear Safety Authority**

to

Departmental Prefects

**Ref:** DGPR/SRT/MSNR/SN/2009.132

**Object:** Management of former uranium mines

For many years, former uranium mines have been subject to special attention from the public authorities, notably the Ministry of Ecology and the Nuclear Safety Authority which consider that these sites should be part of a monitoring process and, where appropriate, a restoration process aimed at limiting their impact on public health and environmental quality[1].

A verification recently conducted by the Directorate General for Risk Prevention in conjunction with the Nuclear Safety Authority shows that these sites have been the subject of a follow-up by the administration, with, in some regions, significant actions that are generally in accordance with a consultation process involving all parties concerned.

Regarding the extension of the actions already implemented, we believe it is now necessary to decisively pursue the management of former uranium mines. In this perspective, our services have defined an action plan comprising the following measures:

1. Check former mining sites
2. Improve knowledge of impacts on the environment and health from old uranium mines and their monitoring
3. Manage tailings: provide a better understanding of their uses and reduce impacts if necessary
4. Intensify information and consultation

[1] The law of 28 June 2006, Decree no. 2008-357 of 16 April 2008 regarding the sustainable management of radioactive waste, and the National Plan on the management of radioactive materials and waste products (PNGMDR) of 2006, including its updated version currently being revised, contain provisions taking into consideration the problem issues posed by these sites.

At the request of the Minister of State, Minister of Ecology, Energy, Sustainable Development and the Sea, responsible for green technologies and climate negotiations, the President of AREVA NC is committed to the implementation of an action plan (see letter PrD - 09/176 of 12 June 2009, a copy of which is attached) that will contribute to the structuring of these 4 measures alongside the actions conducted under the aegis of the State's services.

The majority of these actions will have to be largely under way as of the first year. We attach a great deal of importance to the fact that the implementation of this action plan must be associated with a true consultation process: the need for consultation must therefore be a priority in your working methods.

Lastly, the implementation of this action plan requires working within a coordinated framework, especially regarding the verification of old uranium mines and the surveying of areas with reclaimed mine tailings in the environment, so that vigorous, harmonised methodologies can be implemented at all sites.

**a- Check former mining sites**

In conjunction with the Nuclear Safety Authority (ASN), the DRIRE and DREAL must check the primary mining sites listed in the MIMAUSA database (see www.irsn.fr). The 17 residue storage sites are mandatorily checked as part of this action, as well as all sites that have operated processing plants or passive treatment platforms. Other sites may also be checked because of their sensitive nature. Checks at sites listed in MIMAUSA as "small sites conducting research", "small sites conducting reconnaissance work" or "segmented", and at which no uranium was extracted have a lower priority.

Checks will focus in particular on access, enclosures, the reuse of tailings, terms of environmental monitoring, the general status of sites, and containment devices; they will include checking that devices designed, as the case may be, to prohibit or limit access to the sites and limit their impact on health and the environment, are implemented in accordance with commitments made by AREVA NC, and the provisions you have adopted. Where applicable, these inspections may lead to identifying "sensitive" areas to which access should be protected. In this case, the operator will be asked to expedite the work required and these protective measures will be imposed by a prefectural ordinance.

Random sampling campaigns and measurements of both water and sediments will be conducted for these inspections. These checks can be performed on points regularly monitored by the operator, as well as on "specific" points identified by the inspection. Water flows, including at the foot of rock piles or ore processing tailings, should be given special attention. These inspections may also be carried out outside the mining sites.
The responsibility for the environmental monitoring of mining sites lies with the operator. In addition, and in extending customary practises, these random sampling campaigns and measurements will be decided through inspections, conducted by the IRSN or any other ASN accredited body, with the operator bearing all financial costs.

**b- Improve knowledge of impacts on the environment and health from old uranium mines and their monitoring**

The acquisition of knowledge related to former uranium mines constitutes an essential step in their management. We must also acknowledge that knowledge of these former sites is currently perfectible. This is why the Minister of State, Minister of Ecology, Energy, Sustainable Development and the Sea, responsible for green technologies and climate negotiations, has asked AREVA NC to intensify, within three years, the environmental inventory of all sites for which it holds an administrative licence or a land deed. Special attention must be paid to sites that were previously not operated directly by AREVA NC, and sites at which waste (other than mining waste) was stored in the past.

Furthermore, we invite you to request that, by year-end 2009, AREVA NC provide "operating reviews" for its mining claims, as well as for sites that have operated processing plants, mine residue storage areas, or passive treatment platforms (these reviews must be carried out on a scale adapted to the local context: they can, if necessary, be implemented on a departmental scale, as has already been initiated in the Limousin region). Sediment deposits situated downstream from the sites targeted above must be taken into consideration in these analyses, both in watercourses and water bodies. Based on these operating reviews, appropriate requirements will be imposed on the operator within one year of the submission of this study to improve the environmental impact of these sites and/or intensify environmental monitoring.

Moreover, as part of the application of the national plan for the management of materials and recyclable waste, in early 2009 AREVA submitted studies on the long-term impact of mine residue storage sites. We will inform you of the decision the Nuclear Safety Authority will submit to the Minister during the summer concerning these studies and the requirements you may consequently have to adopt, regarding the analysis undertaken jointly by the ASN and the Ministry's services of the Directorate General for Risk Prevention, if necessary based on additional expert reports.

Lastly, a Pluralistic Expertise Group (GEP) was instituted in 2006 to inform the public authorities on the management of mines operated in the Limousin region. The GEP must submit its findings by year-end 2009. Some results of these works will need to be generalised to all former uranium mines, and may thus also be subject to requirements imposed on the operator. We will inform you regarding this matter during the month following the submission of the GEP Limousin findings so that you can take it into account in the best manner possible within this process.

During the process that will lead you to impose these requirements, the following objectives will be pursued (as part of a measure corresponding to the issues):

- reduce loose emissions and improve the processing of waste (by focusing on "gentle techniques"), particularly regarding impacts on the surrounding environments;
- continue the reclamation of old sites that require it with the aim of their achieving their perfect integration into their local environment and over the long term;
- re-evaluate environmental monitoring for all mining sites (their annexes, treatment facilities and the storage of tailings, etc.) in order to, as applicable, define a monitoring approach that is even better adapted to local needs.

**c- Manage tailings: provide a better understanding of their uses and reduce impacts if necessary**

In uranium mine environments, tailings were generally reused as backfill. This was a commonly accepted practice. However, in 1984 regulatory standards were imposed on the operators of uranium mines, above all to ensure the traceability of the places in which these tailings were used. Then, in 2002, operators of uranium mines definitively stopped this practice.

Tailings from former uranium mines have a radioactive marking. The reuse of these tailings in the environment can, over the years, render soil usage no longer compatible (e.g. housing construction at the base of such embankments).

Whereas we consider that, generally speaking, we should not question past usage, on the other hand we believe it is now necessary to:

— prohibit any new projects which include the use of tailings from old uranium mines;
— establish easements on lands with significant deposits of tailings from old uranium mines, on the one hand to census them, and on the other hand to prevent their usage outside of the land on which they are currently stored;
— conduct a survey of the places where tailings were used outside the perimeter of the old mines;
— obtain information on the uses of the lands on which tailings were reused outside the perimeter of the old mines;
— verify the compatibility of uses at the base and in the immediate environment of areas where tailings have been used.

The operator is responsible for conducting the survey on the places where tailings have been reused (subject to prior agreement with owners of the land parcels affected by the presence of tailings) and in conformity with the commitment made by the President of AREVA NC in the letter she addressed to the Minister of State on 12 June 2009 (a copy of which is enclosed). However, this survey must be conducted as part of a concerted approach involving local information and monitoring commissions (CLIS), as well as the public and local elected officials. We would be grateful if you made certain of this.

AREVA NC will proceed with this survey within two years, for all former uranium mines (the survey method, however, will be developed, qualified and implemented over a third of the areas to be investigated within one year). This survey will then be presented to the CLIS and subsequently made available to the public in the municipalities concerned by the reuse of these tailings. During this period, the public must be in a position to submit observations on this survey. At the end of this period of consultations, AREVA NC will take this information into consideration to complete the survey.

We inform you that, as part of the "MIMAUSA" programme (see inventory available at www.irsn.fr), we intend to appoint the IRSN for counter valuations on some sites of primary importance. The purpose of these counter valuations is to help us judge the quality of the survey conducted by the operator and make this database reliable. Where appropriate, they may also lead you to request that the operator collect further data.

Once this survey has been completed, the uses of land on which tailings have been reclaimed (and in the immediate environment of these reclamation areas) will be checked to ensure that they are acceptable in environmental and health terms. In the event of incompatible usage, AREVA NC will participate in the necessary corrective actions on a case by case basis, as agreed with the Minister of State. Insofar as certain provisions of the Public Health Code will be applied, these

situations must be managed in conjunction with the Departmental Directorate of Health and Social Affairs and the Nuclear Safety Authority.
In the event that tailings must be removed from their place of use, they should preferably be returned to the site from which they originated (which will be authorised under Section 1735 of the nomenclature on classified facilities for the protection of the environment, or for which prefectural ordinances under the Mining Code already provide a framework for the storage conditions of these materials), or to any other site authorised to receive this type of waste, taking into consideration the principle of proximity.
Lastly, the purpose of this survey is to make the information available to the public (in the MIMAUSA database available at www.irsn.fr) and to quickly find, under your guidance, variations in the local development plans of municipalities where tailings of old uranium mines have been recovered, in order to prevent incompatible projects from continuing to develop on sites where these materials were reused.

**d- Intensify information and consultation**

We would like AREVA NC to put up signs at each of the sites listed in the MIMAUSA inventory, to inform the public of the presence of former uranium mines. These signs should properly cover the periphery of each site, providing information on radiological monitoring undertaken. The signs should be maintained and serviced over time, and should be visible during inspections conducted by the Regional Directorates for Industry, Research and the Environment, or by the Regional Directorates for the Environment, Planning and Housing.
The results of radiological monitoring, and generally the measurements taken in mine environments must be submitted annually to the attention of municipalities and local information and monitoring committees. You must especially ensure that the signs set up are maintained and serviced over time.

As already mentioned above, we attach a great deal of importance to the implementation of this action plan in bringing together in the best way possible all stakeholders involved in this issue. At a national level, the working group responsible for developing the National Plan on the management of radioactive waste and materials must be involved in this necessary dialogue. At a local level, we invite you to re-evaluate (regarding technical and environmental issues, or expectations expressed locally by the company) the possibility of creating local information and monitoring commissions (CLIS) or similar structures around sites which do not yet have them, creating them as quickly as possible where they are lacking. If necessary, you may also make reference to health and technology risks at departmental council meetings, or with multiparty groups that can exceed the framework of a site or department (see the case of the Limousin Pluralistic Expertise Group).

We invite you to broadly involve the CLIS and, more generally, local populations and elected officials, in the implementation of this action plan.

* * *

The management of old uranium mines falls within the jurisdiction of the Regional Directorates for Industry, Research and Environment or Regional Directorates for Environment, Planning and Housing. The implementation of these actions can be supported by the provisions of the Mining Code (see article 77 et seq. of the Mining Code, specifically Article 79 which also applies when there has been only exploratory activity), by the provisions under Article R512-31 of the environment code for sites recognised as facilities classified for environmental protection purposes, and by Title IV Part V of the environment code regarding tailings reused as embankments outside the areas of former mines. In the event of very special cases not covered by these regulatory instruments, and therefore exceptionally, the provisions under Article L. 514-4 of the environment code may be adopted. Moreover, and taking into consideration the specific requirements of the former uranium mines, you may make use of the services of the Nuclear Safety Authority in implementing this action plan, particularly in ensuring consistency with the principles of radioactive waste management.

Please inform us of any difficulties you might encounter in the implementation of this action plan. Furthermore, we would be grateful if you could submit a report every six months on the implementation of this circular, and until the completion of this action plan.

Minister of Ecology, Energy, Sustainable Development and the Sea, responsible for green technologies and climate negotiations

**Jean-Louis BORLOO**

President of the Nuclear Safety Authority

**André-Claude LACOSTE**

**ANNEX 4**

**SUMMARY OF THE RESULTS AND CONCLUSIONS OF A STUDY TAKING INTO CONSIDERATION 4 SCENARIOS FOR THE REUSE OF MINE TAILINGS IN THE PUBLIC DOMAIN (AREVA NC, 2008)**

## DOSIMETRIC EVALUATION OF EXPOSURE SCENARIOS

The mining of uranium has led to the existence of areas of radioactivity at some sites which exceed levels attributable to natural background. These situations are encountered at mine sites or in their periphery, as well as in a wider area, due in part to the reuse of mine tailings, and in part to the transfer in the water courses of uranium and radioactivity released by the mining sites, leading to their accumulation in the sediments of lakes or ponds downstream. Depending on their location and their usage, the existence of these areas can lead to the public's exposure. Based on available data and knowledge of situations that have been investigated, various types of exposure scenarios can be defined in assessing corresponding doses of exposure. Dosimetric calculations performed in this manner are not intended to provide an assessment rendering an accurate account of each of the situations encountered. Their aim is rather to assess the extent of the doses received for exposure scenarios that are representative of actual situations. The types of exposure scenarios are based on the use of tailings as backfill material. The average content of uranium in mine tailings is 0.1 g/kg or 100 ppm. The value of 100 ppm in natural uranium corresponds to a per kg activity in U-238 of 1200 Bq/kg. This value corresponds to the maximum uranium content stipulated by the procedure implemented as of 1984 by COGEMA to control the disposal of mine tailings. In taking into consideration the reclamation of areas situated close to ore processing plants or storage areas at which these residues may be scattered, a solution which proposes a mixture of tailings and residues has also been considered as a possible variant for one of the scenarios examined.

### PRIMARY EXPOSURE PATHWAYS CONSIDERED

The following exposure pathways were considered for the situations examined:

- external exposure to radiation emitted by radionuclides in materials from mining operations;
- internal exposure by inhalation of radon in the air in confined spaces (considered negligible for exposures in the open air due to dilution in the atmosphere);
- possible internal exposure by ingestion of soil;
- inhalation of radionuclides following a resuspension of dust has also been considered. However, calculations show that associated doses are negligible for the dust levels corresponding to the situations examined. This pathway was therefore not pursued further.

### EXPOSURE SCENARIOS EXAMINED

Taking into consideration different types of human activities likely to be implemented in the vicinity of former uranium mining sites, four scenarios were considered representing the most significant exposure situations:

- passage of a pedestrian on roads filled with mine tailings;
- outdoor activities on land filled with mine tailings and the addition of a covering (football stadium, car park, playground, etc.);
- living in houses built on embankments made of mine tailings;
- storage of mineral specimens at home.

## SUMMARY AND CONCLUSIONS

These exposure assessments were performed from a dosimetric quantity (effective dose) which is representative of impacts on health, in accordance with the international system of radiological protection.  They have allowed for the formulation of a hierarchy of exposure scenarios to mine tailings for the public. The four scenarios examined and the parameters used for calculations cover a range of situations representative of the diversity of situations around mining sites. The results of corresponding assessments provide threshold values for exposure levels, as well as the relative importance of exposure pathways. In particular, they allow for the identification of situations requiring special attention. Effective doses calculated in these different scenarios can be compared and put into perspective with those received in various situations (occupational, medical, natural, accidental exposures). The different scenarios analysed above can be ranked in descending order according to the importance of their dosimetric impact on the population.

- Buildings built on mine tailings constitute situations where impacts are potentially most relevant. Added external exposure leads to estimated individual doses of from 0.5 mSv/year to more than 1 mSv/year depending on the content of the backfill and embankments. In addition, radon concentrations above 1000 $Bq/m^3$, and in some cases approaching 10 000 $Bq/m^3$, are likely to be observed in some parts of houses built on one level or in basements, since mine tailings are a source of radon in addition to that naturally present on the granite. Doses received by the occupants of these houses may exceed several tens of mSv/year. When concentrations which exceed the reference values for public places are observed, action should be taken to reduce radon concentrations in homes.
- The frequent presence of the public in areas that have been backfilled with mine tailings outside buildings is a second type of problematic situation. In a variety of different places, such as a schoolyard or town square without a ground cover, people and especially children are likely to be exposed to 0.1 to 0.5 mSv per year. In all cases, the doses are below the dose limits for the public established by the Public Health Code (1 mSv/year). Furthermore, it is not excluded that mine tailings or materials containing levels exceeding the value of 100 ppm used in calculations (e.g. blocks of residues) may exist locally, thus leading to individual doses approaching 1 mSv/year. Verifications aimed detecting such situations are therefore recommended.
- The conservation of uranium mineral specimens at home is a special exposure situation which must be analysed on a case by case basis, leading, where necessary to the removal of samples by the competent authorities. In fact, depending on the uranium content in the ore and exposure conditions, the dose may approach or exceed the regulatory dose limit set for the public (1 mSv/year).
- Other situations in which mine tailings have been used as backfill in areas with little traffic (car parks, roads) result in a very low dose impact, in the order of a few hundredths of mSv/year maximum. No particular actions are required in these cases. All of these dosimetric evaluations were performed using a uranium concentration of 100 ppm in the tailings. For higher concentrations of uranium in tailings, the level of the doses received by the public will be proportional to the uranium content in the tailings. Lastly, these dosimetric evaluations provide a model of the radiological impacts on population groups, and cannot be applied without precautions to special situations or any given individual.

**ANNEX 5**

## LETTER OF 12 JUNE 2009 FROM AREVA NC ADDRESSED TO THE MINISTER OF STATE

AREVA

Paris, 12 June 2009
PrD-09/176

Object: Action plans for maintaining the monitoring of former uranium mines

To: The Minister of State,

Together with AREVA NC, you have sought to adopt an action plan in order to continue the monitoring of former uranium mines in France and improve information and consultation on the management of these sites. AREVA NC fully shares this objective and wishes to continue the actions undertaken for several years now in partnership with the State services, promoting a transparent management towards stakeholders, and in compliance with regulatory requirements and agreements applicable in this area.

To this effect, AREVA NC will emphasise the following elements:

CEA, and later COGEMA, which became AREVA NC, operated a part of the uranium mines in France for nearly half a century. The other sites were operated by companies which do not belong to the AREVA Group.

In the early 1990s, following its decision to cease its operation of uranium mines in France, AREVA NC initiated redevelopment work with the aim of rendering the mine sites safe, reducing their radiological impact, integrating them into the landscape, and promoting their reuse in compliance with mining regulations and facilities classified for environmental protection purposes. Within this framework, the administration delivered to AREVA NC the relinquishment, abandonment and declaration of the definitive stoppage of works.

A pioneer in the redevelopment of uranium mines, AREVA NC joined forces with numerous internationally renowned partners and scientific bodies: the Centre for Research and Study on the Geology of Uranium (CREGU), the Ecole des Mines de Paris [Paris School of Mining], CNRS and universities. This work was also conducted under the supervision of the administration (DPPR); to this end, the regulatory standard regarding the redevelopment of processing residue storage sites can be cited. To achieve this, AREVA NC implemented a dedicated service in Bessines (CESAAM), on the very site of a part of our former activities, so as to ensure the monitoring of mining sites.

Furthermore, AREVA NC has always believed that the redevelopment of mines, as for all of our industrial activities, should be implemented in consultation with neighbouring populations. This is why AREVA NC participates in the dozen or so Local Information and Monitoring Commissions (CLIS) instituted around the mining sites to respond to the questions of residents.

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Moreover, a Pluralistic Expertise Group was created in 2005 for our sites in Limousin (GEP), under the initiative of your Ministry, comprising representatives of associations, universities and international experts, with the task of informing the administration and AREVA NC on management and monitoring options at the sites. AREVA NC participates fully and actively in these works, responding to each of its questions. The GEP will submit its final report at year-end 2009, presenting its findings and recommendations to government bodies.

The redevelopment of uranium mines has given rise to several reports and studies compiled either at the request of the Ministries concerned, the Parliament, associations, the Public Health Council of France, the IRSN... and yet, to this day none has detected any health or environmental problems which might lead to question the redevelopment of the sites and their monitoring.

Within this context, and to respond to your question, AREVA NC strongly wishes to renew its commitment to the implementation of the following actions:

1. Intensify the prevention of intrusions at AREVA NC sites;
2. Improve knowledge of the sites and, if necessary, of their environmental impacts;
3. Survey areas where radiologically marked tailings from mining activities have been reused, and participate in the reduction of impacts;
4. Promote information and consultation.

These commitments are in line with the actions of local redevelopments already implemented for over a decade now.

The conditions for the implementation of these actions are described in the Annex herein.

Lastly, AREVA NC proposes that you account for the implementation of these actions within the High Committee for Transparency and Information on Nuclear Safety, if its President accepts.

Please accept, Mr. Minister of State, the assurances of my highest consideration.

Anne Lauvergeon
Chair of the Board of Directors

*Copies:* *The Head of Mission of nuclear safety and radiation protection*
*The. President of the Nuclear Safety Authority*

The Minister of State
Ministry of Ecology, Energy,
Sustainable Development
and Territorial Planning
(MEEDDAT)
Hedel de Roquelaure
246, Boulevard Saint-Germain
75007 PARIS

## ACTION PLAN

AREVA NC states that contrary to the storage of residues, which are all owned by AREVA NC, the holding of numerous land parcels occupied during the mining phase was returned to their owners or sold to other owners, since mine operators generally act solely as licensees. From this point onwards, AREVA NC cannot legally intervene on the lands of third parties of which it is neither an owner nor a licensee.

Furthermore, AREVA NC, a commercial company under private law, does not hold administrative policy powers, and in this respect the group can only be involved within the limits of its powers. As such, the actions listed in the action plan will be implemented in compliance with legal and regulatory obligations that are the responsibility of the authorities and operators.

The implementation of this action plan, taking into consideration its geographical perimeter, leads AREVA NC to act within a coordinated framework at a national level, so that harmonised methodologies can be implemented for all sites.

### a/ Intensify the prevention of intrusions at AREVA NC sites

The goal is to further intensify the prevention of intrusions at ore processing residue storage sites, and in areas presenting risks relating to the safety of land on which former uranium mines are situated.

- AREVA NC agrees to maintain and if necessary complete the fencing around the perimeter of uranium ore processing residue storage sites that are classified facilities for the protection of the environment.
- In addition to these sites, AREVA NC will re-evaluate situations which should lead to the fencing off of certain areas at other sites of old uranium mines: these may include securing areas against classic risks such as mine collapses or falls.

This operation, which was begun many years ago, should be completed towards the end of the third quarter of 2009 for residue storage sites, and will be completed, if necessary, at other sites, in relation to findings prepared for environmental analyses pursuant to the following paragraph (§ b-).

### b/ Improve knowledge of the sites and, if necessary, of their environmental impacts

AREVA NC will consolidate the environmental inventory of sites for which it is the current holder (administrative authorisation, property deed). A list of these sites will be provided to the Ministry's services as well as to the Nuclear Safety Authority within two weeks.

This inventory will be formalised by drawing up departmental budgets on the existing model for sites in the Limousin region, as well as by taking into consideration the findings released by the Limousin Pluralistic Expertise Group and the analyses conducted based on Decree no. 2008-357 of 16 April 2008 regarding the national plan on the management of radioactive materials and waste products. In particular, these reviews will analyse the possibility of optimising the treatment of waste products (focusing on "gentle techniques") at sites which require it.

These reviews will be conducted within three years according to a schedule proposed by AREVA NC to MEEDDAT and the Nuclear Safety Authority (ASN), and presented at CLIS meetings and consultations with bodies interested in old uranium mines (see § d-).

The Bauzot site (Saône et Loire) at which non-mining waste has been stored, as described in the national inventory by ANDRA, will be given priority consideration.

AREVA NC also agrees to propose a sustainable redevelopment of the site of Bois Noirs Limouzat (Loire) so as to overcome the limitations posed by the presence of a tall embankment, in compliance with the schedule AREVA NC has already committed to within the CLIS. Containment under water will be replaced by another technique, offering the best guarantees of security and sustainability.

**c/ <u>Survey areas where radiologically marked tailings from mining activities have been reused, and participate in the reduction of impacts</u>**

In environments in the vicinity of uranium mines, low tonnages of tailings have been reused as embankments to respond to the demand of residents and local authorities. This was an accepted practice and there are no plans to challenge it in its entirety.

It should be noted that until 1984 this practice was carried out without any constraints. From that date onwards, at the request of AREVA NC the use and disposal of tailings has been managed by a specific control and traceability procedure established jointly with the radioprotection authority. Then, as of 1990, the management of tailings on site was conformed to Decree no. 90-222 of 9 March 1990, which stipulates the implementation of a management plan for materials with levels exceeding 300 ppm. Since 1992, AREVA NC has halted all transfers of radioactively marked tailings from old uranium mines.

As such, AREVA NC considers that it is now necessary to:

- identify places where such radiologically marked tailings have been reused in the vicinity of the perimeter of old mines;
- identify by field actions and based on available information, land uses where radiologically marked tailings were reused outside the perimeter of the former uranium mines.

This survey must be conducted in a concerted process and jointly with the CLIS and local populations and elected officials, and framed by the administration. It may be presented to the CLIS and subsequently made available to the public in the municipalities affected by the reuse of these tailings.

In 2009, AREVA NC will proceed with the qualification of the survey methodology by aerial radiometric detection in the Limousin region, which will cover a surface area of some 1000 $km^2$. If this method proves suitable, it will be extended in 2010 to an additional 2000 $km^2$ roughly. As for the results of this detection operation, controls will be conducted in the field and submitted to the administration (Ministry and prefectures concerned). Within this process, AREVA NC will verify the compatibility using the soil where tailings have been used. In the event of incompatibility, AREVA NC will inform the administration. In the event of the survey's continuation or of incompatibility, AREVA NC will participate in the management of such situations, jointly with the administration and on a case by case basis.

AREVA

**d/ Promote information and consultation**

AREVA NC agrees to pursue and promote information and consultation around former uranium mines.

To this end, AREVA NC will post signs to inform the public of the presence of sites subject to radiological monitoring, jointly with the local authorities, CLIS and, where applicable, individual persons.

The results of regulatory monitoring measurements will be posted on the RNME website (National Network for the Measurement of Radioactivity in the Environment), and will generally be made known to the CLIS (or any other similar consultation body), and municipalities concerned.

AREVA NC will make available its expertise during the installation of the CLIS for mining sites for which no consultation has been implemented.

AREVA NC proposes to present the implementation of its action plan to the High Committee for Transparency and Information on Nuclear Safety.

**ANNEX 6**

## URANIUM MINING SITES IN HAUTE VIENNE

| MINING SITES | Production period | Surface area affected | Current activity | Regulatory monitoring requested by prefectural ordinance |
|---|---|---|---|---|
| Montulat | 1979 to 1983 | 23ha 17a | Diving club | No |
| Villard | 1972 to 1973 | 5ha 63a | Former rubbish dump | No |
| Bessines Industrial Site | 1955 to 1972 | 159ha 00a | Offices, WTP, WPS, restaurant, archives, monitoring services<br><br>SEPA, ALGADE<br><br>Depleted U storage | Yes (under the ICPE) |
| La Traverse | 1990 to 1991 | 14ha 62a | None | No |
| Point 117 | 1969 to 1972 | 6 ha 78a | None | No |
| Bellezane | 1975 to 1992 | 117ha 48a | WTP, 2 companies | Yes (under the ICPE) |
| Les Petites Magnelles | 1991 to 1992 | 38ha 96a | None | No |
| Le Puy de l'Age | 1977 to 1993 | 17ha 33a | Fishing club | No |
| Puy Teigneux | 1990 to 1991 | 14ha 78a | WPS | Yes |
| Montmassacrot | 1976 to 1981 | 12ha 72a | WPS | Yes (under the ICPE) |
| Chanteloube | 1964 to 1979 | 17ha 47a | None | No |
| Champour | 1985 to 1986 | 6ha 74a | None | Yes |
| Le Roudet | None | 0ha 59a | Municipal workshop | No |
| Santrop | 1983 to 1984 | 5ha 14a | Agriculture | No |
| Bachellerie | 1976 | 2ha 81a | Agriculture | No |
| Silord | 1976 to 1990 | 8ha 36a | WTP | Yes |
| Fanay / Augères | 1951 to 1992 | 140ha 23a | WTP | Yes |
| Henriette | 1949 to 1981 | 20ha 90a | None | No |
| Le Fraisse | 1965 to 1990 | 52 ha 67a | WPS, WTP, COREIS | Yes |
| Les Gorces-Saignedresse | 1977 to 1991 | 33ha 72a | Municipal activities | Yes |
| Margnac - Pény | 1953 to 1995 | 200ha 22a | WTP, mini power plant (PNY), Municipal activities (CTM) | Yes |
| Vénachat | 1959 to 1992 | 42ha 80a | Firefighter training centre | Yes |
| Bonnac-la-Côte | None | 12ha 40a | Agriculture | No |
| Le Dognon | | 3ha 25a | Agriculture | No |
| Le Bernardan | 1978 to 2001 | 193ha 53a | WTP, artisanal areas | Yes (under the ICPE) |
| Les Loges | 1985 to 1998 | 26ha 00a | Hunting preserve | Yes |
| Piegut | 1979 to 1985 | 04ha 48a | None | Yes |
| Cote Moreau | 1980 to 1982 | 05ha 85a | None | Yes |
| Masgrimauds | 1982 to 1986 | 12ha 40a | Diving club | Yes |

***WTP: water treatment plant*** ****WPS: water pumping station***

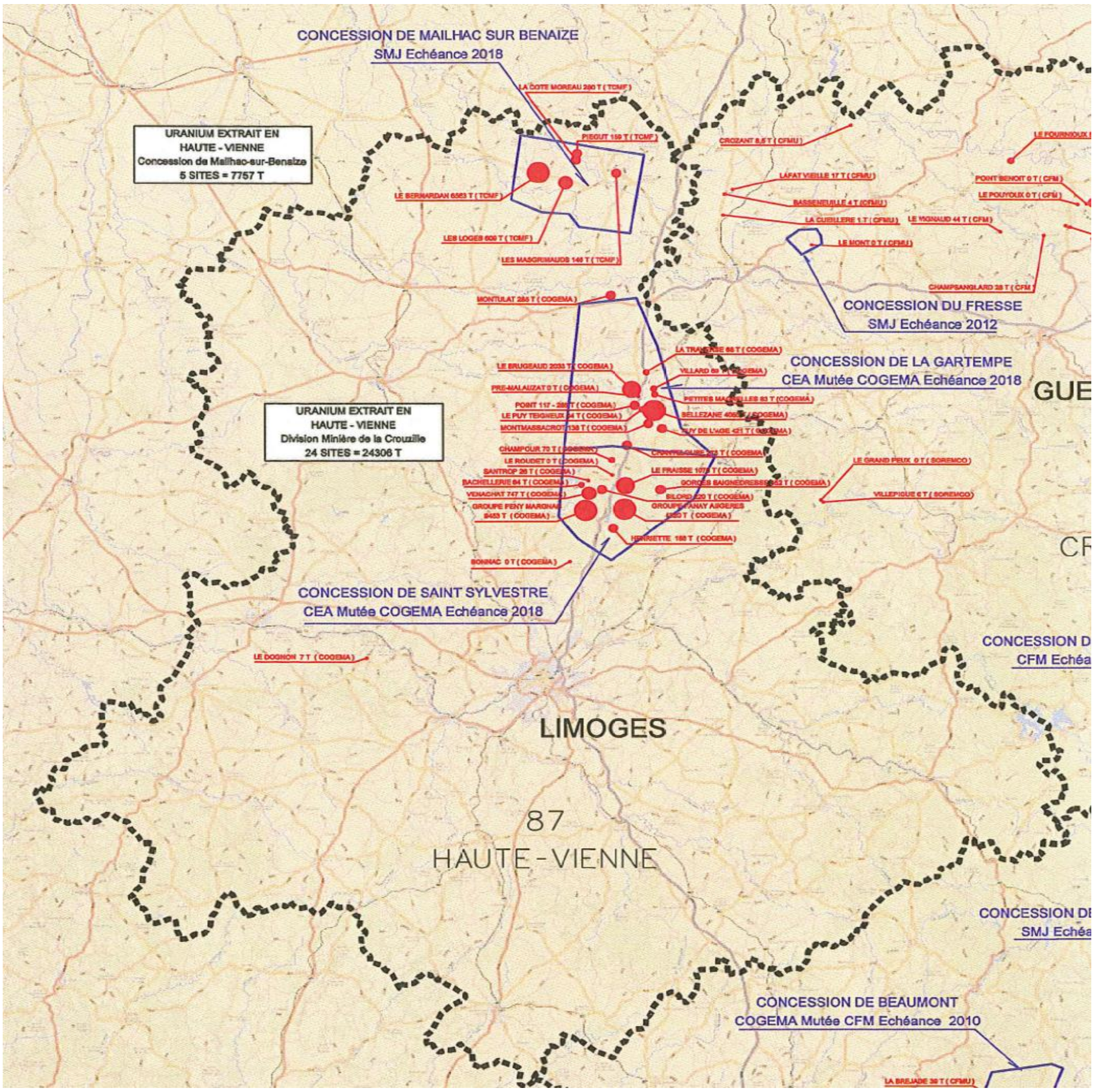


Figure: Uranium mining sites in Haute Vienne (©AREVA)